# A Study in Laterality among Retarded Children.

Thesis

presented by

Isabella Clark Sharpe nee MacLean, M.A., B.Ed., (Edin.)

for the degree of

Doctor of Philosophy.


1953.

Acknowledgments.

I desire to acknowledge my general indebtedness to Dr. McIntosh, the Director of Education for Fife, for permission to use data obtained on children in Fifeshire.

# C O N T E N T S.

## List of Tables

## List of Figures.

## List of Illustrations.

### Appendix A.

## List of Tables.

### Appendix B.

## List of Tables - (Contd.)

### Appendix B.

## List of Tables - (Contd.)

### Appendix B.

# Chapter 1.

## Introduction.

Laterality is a generic term. It includes the bodily behaviour characterised by the unilateral preference of the external bipartite organs. The type more commonly observed is that shown in the preferential use of one hand. Thus people are designated as right or left handed or ambidextrous, in so far as they predominantly use the right or left hand or perhaps both hands, with equal frequency. Similarly individuals show preferences in vision. Some sight with the right eye or the left eye or both eyes with equal frequency. Included in body laterality are foot preferences and 'preferred sidedness' of the body but fewer studies have been made of those aspects possibly because satisfactory criteria are not available. Ear dominance has been considered in a few cases but the difficulty is to distinguish between 'acuity' and dominance.

The brain is organically structured with two halves or hemispheres connected by nerves and muscles to the opposite sided limbs, but one hemisphere is regarded as the 'major' or dominant while the other is the 'minor' or non-dominant hemisphere.

Underlying most discussions of Laterality is the assumption explicit or tacit, that handedness, eyedness

etc. are manifestations reflecting 'hemispherical cerebral dominance'. The conception of complete cortical dominance implies a consistent dominance existing in eye, ear and hand which is dubious. That hand and eye would agree if Nature were left undisturbed or thus, that Laterality in the natural state is consistent for all bilateral functions is difficult to verify experimentally. The placing of people into two categories of pure Dextrals (i.e. Righthanded: Righteyed) and pure Sinistrals (i.e. Lefthanded: Lefteyed) is an oversimplification of the problem as there appear varieties of Crosslaterals (i.e. Righthanded: Lefteyed or Lefthanded: Righteyed) with people Ambilateral both in hand and eye. This feature of Crosslaterality becomes important when the acquisition of language skills is involved. With young children there frequently occur examples of lack of oculo-motor control as in mirror writing or tendencies are shown where figures and letters are written in reversed order or generally confused, a condition recognised as static strephosymbolia. Difficulties in the serial order of letters within syllables and words, and words within phrases may lead to complete reversal of palindromes etc. - characteristic of kinetic strephosymbolia, while spelling and other forms of written work seem wellnigh impossible for many of these types. With many of these children there likewise appears present a general awkwardness or gaucheness in muscular control and movement. It becomes

thus of prime importance to teacher and parent to decide how a child should best be trained in hand and eye skills, if the laterality of an individual or the relationship of hand and eye determines to a certain extent his efficiency in living. Observation of these difficulties in children over the previous fifteen years in field work, first as a teacher and then as a clinician convinced the writer of the necessity for further study of the condition of Laterality. Why does left handedness persist with some children despite efforts to change the handedness? What are the results when handedness is changed or is imperfectly changed? Do right handed children differ significantly from left handed in any specific fashion? Do the brain mechanisms which underlie lateral expression appear to differ greatly in sinistral and dextral individuals? These and many other questions require adequate answers. The present study was undertaken in an attempt to analyse some of the causes and to gain further insight into problems pertaining to Laterality.

.....

In the investigation specific groups of children were chosen for study and their Laterality characteristics were examined. The work falls into five main sections. In the first section, a Background Situation is reviewed with reference to the Intelligence and Achievement levels of

all the children examined. This was essential in order to establish the extent of retardation present. The second section deals with Laterality and its manifestations in the groups. Especial reference is made to the relationship of Laterality to the Intelligence and Achievement of the children. An intensive examination of the Twin group has been made by considering them in family pairs, apart from an analysis of them as a Twin Subgroup. The relationship of Laterality with Speech has likewise been examined. The third section deals with the relationship of Laterality to Temperament. The emotional aspects of the groups are examined to estimate the association if any. In the fourth section are discussed the tests of Laterality used, and their results. As far as the writer is aware, no report of the Van Riper Test with children in its three aspects of Visual, Script and Kinaesthetic patterns has been made by any worker in this country. Reports have been made of the Van Riper with the Visual pattern or the Script pattern alone. The findings may thus present a new contribution to the adequacy of this test with work on children. The fifth section presents a summary of the findings and the relationship of results to psychological theory. Although the work has been thus divided into sections the unity of the whole has been preserved in that the same children have been studied throughout.

In dealing with the human element one necessarily recognises that qualitative aspects emerge, which cannot be

measured with perfect objectivity, but in the following work an attempt has been made, so far as possible, to carefully accumulate adequate data which can be submitted to strict mathematical treatment and critical analysis. Theoretical implications have been considered as the statistical treatment has led to the psychological realities behind the results of the measurements.

Where comment is made on the results of other workers in this field of research recognition is given by a running number which provides the key to bibliographical reference at the end of the study. A short reference list is also appended at the close of each chapter where necessary.

The report of the study represents the work commenced and systematically carried out over the past six years and more, and is submitted in the hope of contributing in some small measure to psychological knowledge.

## Chapter 2.

## Method of Investigation.

The present study was undertaken to obtain additional evidence on the subject of Laterality and to determine the association if any, between mixed dominance or cross-laterality and difficulties in language ability, specifically in Reading and Spelling.

In an analysis of some of the characteristics of retardation in a group of backward children in Fife, it was observed in Reading and Spelling, that many showed well-defined patterns of what has been termed generally, 'Developmental aphasia'. These children showed evidence of word recognition difficulty, strephosymbolia or twisting of symbols, static aphasia and reversals of letters, syllables within words and words themselves. A general directional confusion in language assimilation seemed evident. It was therefore decided to make a further study of the Laterality of many of those children in an attempt to find out how much they were being handicapped by this factor.

Age Group Chosen.

A group of 570 backward children, age range five years to sixteen years, was surveyed by means of an individual intelligence test and an achievement test in Reading and Spelling. As their average I.Q. lay at approximately the 80 - 85 level, it was decided to

eliminate from the group all children below the chronological age of seven years, as dull children of that age would hardly be ready mentally for Reading assimilation or Spelling. Similarly children above the chronological age of twelve years eleven months were excluded. By that time they had passed from the unitary environment of the Primary School and it seemed that the varied influences of a post primary department would render a study of Laterality and of cross-lateral influences on fundamental subjects, too complex. In actual fact due to circumstances beyond the control of the tester, several children were examined beyond the age of twelve years eleven months. When both ends of the age range were curtailed the percentage of attendance for each child was calculated for the two years previous to the testing and again every child with an attendance below 50% was eliminated. This step together with the enforced elimination of 44 children who had left the County or were untraced further reduced the number to 520, 330 boys and 190 girls. This was regarded as the 'Final Group' or the 'Retarded Group' to be retained for further testing and analysis.

In order to compare this Retarded Group and render it suitable for extraction of relevant factors, it was necessary to obtain a control sample of normal children, a sample which would be similar so far as possible in chronological age, sex, school environment with uniformity

of teaching methods, and similar home environment re town and area. A group of 200 children was finally chosen by the following method. The names of all the Retarded Group children were mixed up in a hat and 200 of these were drawn at random. An attempt was then made to find the child nearest in birthday date in the same school, as the Retarded Group name which had been drawn. In this way a 'Control Group' of 200 was obtained. They were similar so far as it was possible to find them - in age, sex, school and home environment. Twenty of these children had to be eliminated owing to their transfer to other areas so that the actual number in the Normal Group available for further testing and analysis was 180, 100 boys and 80 girls.

In considering Laterality, the investigation of twins suggested a field where much relevant information might be gained. Accordingly all the twins available between the ages of seven years and twelve years eleven months were obtained, 186 pairs plus one. These twins were similar in age, and alike to the previous two groups in that they were pupils of the same schools and home environment, although it was impossible to pair them exactly to a Retarded or Control Group child. Twenty-nine of this group were eliminated as they were not available for further examination: thus 344 twins - 166 boys and 178 girls comprised the Twin Group finally. Thus three groups were available for study totalling

1044 children altogether.

The children came from the same school environments as they were all in attendance in the Primary schools of Fifeshire when first seen - the co-ordinating factor being the policy of education as practised in the County.

The Environment.

As the children came from every part of the County, a cross-section of town and rural education was obtained. Likewise home environments comprised families of fisher folk round the coast, agricultural workers in the North of the County, industrial workers in the towns and miners in the West and South.

Fig. 1 shows the location of the children.

General Procedure.

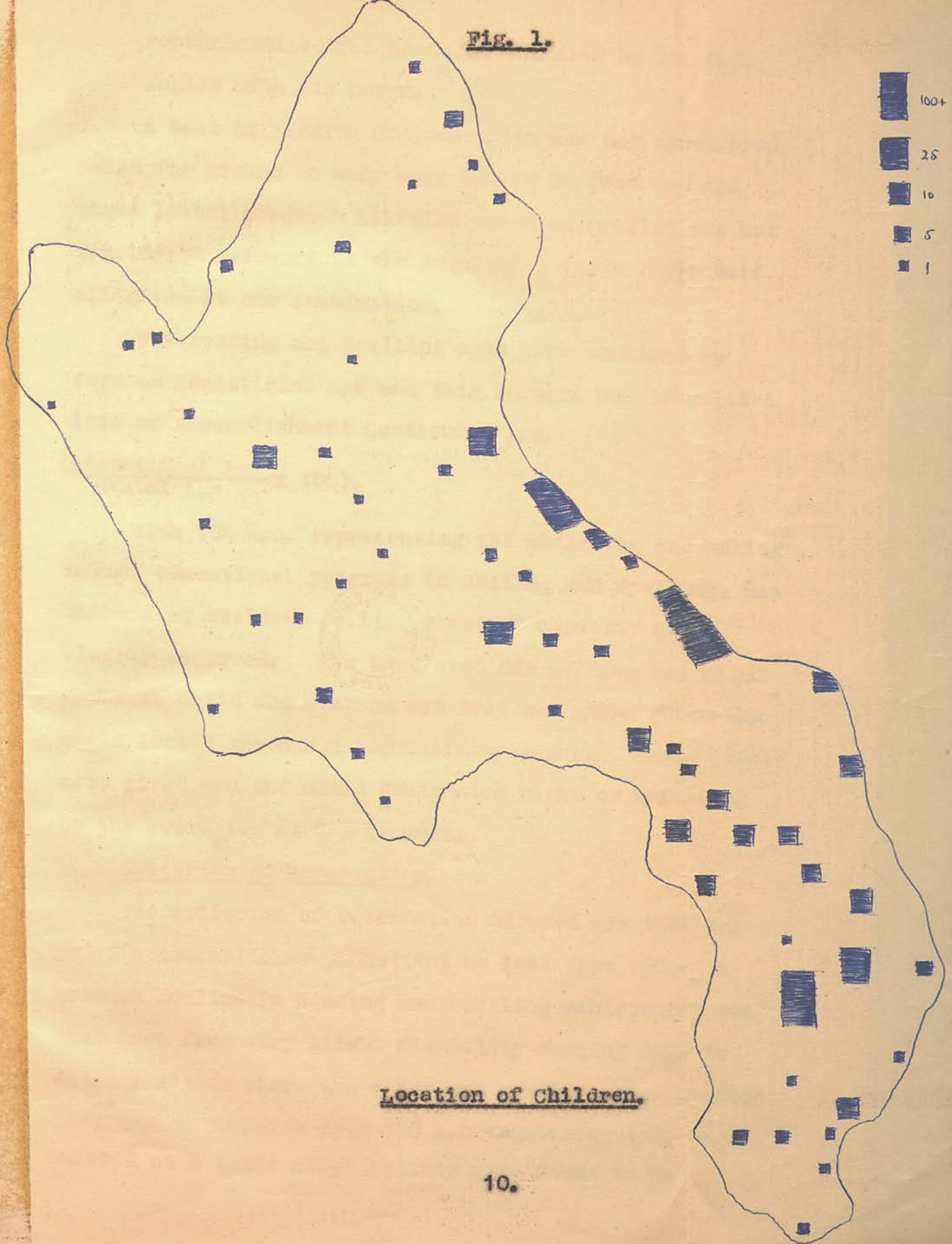
Each of the children in the three groups, Retarded, Control and Twins, had been given -

(a) An individual intelligence test, viz.
Revised Stanford-Binet, 1937 - Form L, by L.M. Terman and M.A. Merrill. (Adapted for use with Scottish children).

(b) Educational tests in Reading, viz.
Burt's (1923, Test I) Graded Vocabulary Test (Accuracy) using the Vernon (1938 a) Revision for Scottish children.

(c) Spelling, viz.
Burt's (1923 Test VI) Graded Vocabulary Test

Fig. 1.




Location of Children.

restandardised for Scottish children by Dr. W.B. Inglis with his norms.

A test of Reading Comprehension was not considered valid for groups as many were unable to read two and three letter words. Likewise speed of reading was not considered relevant to the inquiry. These tests were all given at one examination.

The Reading and Spelling ages were combined to form an Educational Age and this in turn was translated into an Accomplishment Quotient - i.e.

$$\left(\frac{\text{Educational Age}}{\text{Mental Age}} \times 100\right).$$

With 100 A.Q. representing the child who was making normal educational progress in Reading and Spelling, the numbers of children falling short of capacity were clearly observed. The hand used for writing was noted for each child and a short eye test was given where the child looked through a cardboard cylinder. Three trials were given and the child designated Right or Left eyed as the score lay at 2/3 or more.

Criterion of Retardation.

The criterion of retardation adopted was that the child's Accomplishment Quotient be less than 100. A gradual decline in Reading and Spelling achievement was thus seen from very slight disability ranging down to extreme degree where the child was working under severe handicap. Children over 100 A.Q. numbering 120, were omitted at a later stage as they were found to be

non-retarded.

These groups, after a time interval of not less than six months and not more than two years were again examined individually with a parallel form of earlier intelligence scale, namely Terman-Merrill M. The same Reading and Spelling Tests were given and the A.Qs. again computed.

Hand and eye were however studied in much more detail by means of -

(a) A specially prepared battery of 3 Performance Tests (performed with each hand separately) - given twice, firstly in abbreviated form as a Trial Test shock absorber and secondly in Final Form.

(b) Three specially prepared Eye Tests.

(c) Van Riper Critical Angle Board in its three aspects:

1. Kinaesthetic
2. Script
3. Visual

The results on the Performance Tests were scored, added and averaged for each hand, yielding a composite score for Preferred and Non-preferred hand.

Likewise the degrees of mirroring for the three aspects of the Van Riper Test were added and averaged to obtain a Composite score or degrees of mirroring.

In this way a comparison was obtained between the Performance tests of accuracy and precision involving factors regarded as being susceptible to training and

environmental influences and the Van Riper tests which are regarded by their author as capable of determining untrained innate handedness.

The Performance Tests.

In the Appendix A Pages 1a and 2a are given the prepared forms on which the scoring of the Performance Tests were recorded.

(a) Eye Tests.

Three tests were used -

1. Telescope Eye Preference - A toy telescope was used being of sufficient interest for the respective age groups. This was laid before the child and he was invited to pick it up and look through it at a point in the room. Three trials were given, when the child picked up the telescope with each hand and once with both hands. The sighting eye was noted in each trial.
2. Ruler Test - A twelve inch ruler was presented to the child and instructions given to hold it at arm's length. On focussing a point in the room the child was required to bring the ruler nearer and nearer to one eye until it nearly touched. He was allowed to close one eye as the ruler approached his face. Three trials were given as before.
3. T-Hole Eye Preference - A section of wood was shaped like a letter T, the body forming a handle. A hole was cut in the centre of the wing pieces for the

child to see through. The test was given in the form of looking through a hole in a fence. The subject picked up the shaped wood and the eye to which the hole was brought was clearly observed as the wing pieces were sufficiently broad to prevent the subject from looking over the top. Three trials were given as before.

Hand Tests.

Hand preference was observed and measured in three tests. These tests were given first in abbreviated form as a trial test, (see Appendix). Three chances were given on two tests and time measured on $\frac{1}{2}$ minute on the third test, as compared with eight and ten chances on two tests and time measured on one minute in the Final Form.

1. Hoopla Test - Eight rubber rings and a hoopla board, two feet square with three circles painted on it, were used - hooks on which the rubber rings could be held were nailed at even distances on the board, such that an equal chance of scoring in any of the circles was possible. The centre circle scored fifteen, the middle circle ten, and the outer circle five (see Appendix A Illust. 3a for photograph). The board was hung on the wall, level with the child's vision at a distance of six feet. Rings were placed beside the child. The explanation given was that the subject was to throw the rings and try for the highest score possible. The hand volunteered first in throwing the rings was recorded as the Preferred hand. A

further eight throws were given with the Non-preferred hand and a record of the score made by each hand was kept.

2. Bean Bag Test - Ten four inch bean bags were made, with a wooden box twelve inches square, six inches deep, with a circular hole in the top, five inches in diameter. The subject was instructed to throw the bean bags in the box from a distance of six feet. Each time a bag fell in the box a score of ten was given; for a bag falling on top of the box a score of five was given; and if on the floor, no score was recorded. When the subject picked up the first bag, the hand volunteered was recorded as the Preferred hand. The subject continued throwing for ten tries with the Preferred hand and then a further ten throws were made with the Non-preferred hand. Scores for each hand were recorded. (See Appendix A for photograph.)

3. Peg Board Test - A Pegboard was used, nine inches square, with holes each ¼ inch for the pegs, there being sixty-four holes in the board (see Appendix A). A stopwatch was used to time each subject for one minute (½ minute in the trial test.) The subject was instructed to begin putting pegs in the holes when the signal 'go' was given and to continue until the word 'stop' - one hand to be used. The hand volunteered was recorded as the Preferred hand, and

the number of pegs placed in the holes made the score. A similar performance was given with the Non-preferred hand.

The average scores for the Preferred and Non-preferred hands were then calculated by adding the scores on each respective test and averaging. A similar combined score for each hand was obtained for the Trial Test.

In order to lessen the carryover influence of practice effect of the Preferred hand on the Non-preferred, half of the subjects began the tests with the Preferred hand and half began with the Non-preferred hand. These latter were quietly told to 'begin with the other hand' when their hand preference had been noted.

These Performance Tests were chosen specifically because from previous research they had been found to correlate highly with hand dominance for unimanual activity, see Cuff, 1931 (18); Downey, 1933 (23); Heinlein, 1928 (39); Jones, 1926 (50); Haefner, 1929 (36).

The Hand Performance Tests were then followed by the Van Riper Test - The apparatus which can be called the critical-angle board consisted of two writing boards (W.1 and W.2) which were hinged to an upright support so that they could be varied from a position parallel with the chest surface of the subject to a position perpendicular thereto. Paper was fed along each board so that the right hand performance was recorded on the

righthand board and left hand performance recorded on the lefthand board. The boards could be converged through 10°, 20° .....90°, and the appropriate angle or degree at which the mirrored image of the pattern was reproduced represented the critical angle of mirroring and the degree recorded. (See photograph in Appendix A - 4a)

Three Patterns were given -

Kinaesthetic - The Kinaesthetic pattern consisted of Van Riper's Y-shaped groove with the corners more rounded so that the end result resembled the figure of a bear. (See Appendix A - 5a). This slight deviation was found to be necessary in order to overcome a tendency of the bimanual stylus to stick at corners. This formed a handicap to the child as the 'feel' of the pattern could not be gained so easily due to a pre-occupation with a stylus that did not flow readily round the pattern. The bimanual stylus enabled the child to learn the pattern with both hands working as a unit. The pattern was grooved in a board one inch thick, twelve inches long and six inches wide.

The subject was blindfolded and the stylus placed in his hands. He grasped the T-shaped handle with both hands extending the forefingers into the two cups near the point of the stylus. Holding the stylus in this manner he traced the Kinaesthetic pattern until he knew it well enough to draw it. The subjects of this

investigation were timed while learning the Kinaesthetic pattern. This was not done in Van Riper's testings. Still blindfolded, the stylus was then taken away from the subject and a pencil placed in each hand. He was then instructed to draw the pattern which he had just learned, on opposite sides of the board with both hands at once, as quickly as possible. The wing boards on the first trial stood parallel with the subject. After each drawing the boards were moved 10° away from the subject until mirroring of the pattern occurred with one hand. One trial beyond the mirrored pattern was given, as a check. The degree at which mirroring occurred was recorded and the hand mirroring designated with an L or R as the case might be. (Normal expectancy being a mirroring with the Right hand of Lefthanded subjects and vice versa.)

Script Pattern - The subject was blindfolded and given a pencil in each hand. As the experimenter said the word 'cat' the subject was told to write it as quickly as possible with each hand on the respective boards. The wings of the board as in the Kinaesthetic pattern, were moved from the parallel position through 10° intervals until mirroring occurred. One trial was given beyond mirroring. (Van Riper used the word 'catch' but this was found to be too difficult for many of the 'Retarded Group'.)

Visual Pattern - The visual pattern was hung on the wall at an angle of 30° in front of the subject. A

length of cardboard was held between the subject's eyes and hands to eliminate any observation of hand movements. He was instructed to draw the visual pattern before him as quickly as possible while watching it all the time tracing the pattern with his eyes while drawing it with his hands. The wings of the board were moved as before until mirroring occurred. One trial beyond the mirrored pattern was given. (Photograph in Appendix A - 6a)

An attempt was made to regulate the reproduction of the visual pattern to the beat of a metronome. This was abandoned as it appeared to confuse the slower children to whom it was a distracting influence. The visual pattern used was an adaptation used by W.E. Cooper and M.E. Bonney. This alternative version allowed a freer flow of the hand and presented sidedness of mirroring with opportunities for vertical mirroring to appear.

A composite score for Van Riper mirroring was obtained by summing the degrees at which mirroring occurred on each pattern and averaging. A comparison with the Preference hand of the Performance Scores and the hand mirroring on the Van Riper could then be obtained.

## Section I

## Chapter 3 - Analysis of Total Group.

### Background Situation.

While we wish to study the Laterality and the association if any, of mixed dominance or Crosslaterality on language ability in our groups, it is necessary to view the background situation with reference to the Intelligence and Achievement levels of our children first of all. A general analysis of the total retardation situation and the relationship of educational attainment to intelligence has thus been made. Since the problem concerns the aphasic characters of difficulty in school work, measurements of attainment have been used in reference to Reading and Spelling activities only. In selecting tests of Reading and Spelling, consideration was given to the question of utilising a battery with tests of comprehension, speed, dictation etc., but a major obstacle lay in the difficulty of the material for the children of lowest mental age. As comprehension and speed of Reading were not considered of prime importance to the main study of Laterality, it was decided, after deliberation, to use only the Reading Accuracy Test of Burt and to combine the score from this test with the score from the spelling test.

The Accomplishment Quotient has been used to express achievement outwith capacity. Low intelligence may be

operating as a factor in difficulty with Reading and Spelling but by studying the Accomplishment Quotient, the performance of the children as related to their ability can quickly be seen. The Accomplishment Quotient expresses educational age as a percentage of mental age. Thus a child whose A.Q. is 85 will be working to 85% of his natural inborn capacity. With an A.Q. of 95 he will be working to 95% of his capacity, while an A.Q. of 100 signifies attainment corresponding to capacity. In so far then, as the A.Q. falls below 100, there is evidence of work below capacity and therefore interference with learning. The general characters of the Total Group follow:

Level of Intelligence.

The Total Group numbered 1044 children, who were individually examined twice on Intelligence Tests and Educational Tests in Reading and Spelling. Figures and Tables refer to the 2nd Intelligence Quotient and 2nd Accomplishment Quotient, but results on First Testing are also given for interest.

The Total Group consisted of 520 Retarded Group children, 180 Normal Group children, who had been chosen as a control group, and a Twin Group of 344 children. In the Total Group were 596 boys and 448 girls. It was found that 120 of the children were not retarded in that the A.Q. was not below 100, therefore a wide range of backward children was available for study, whose A.Qs. ranged from 100 downwards.

The distribution of the Second Intelligence Quotients for all children in the Total Group 1044, is shown in Fig. 2.

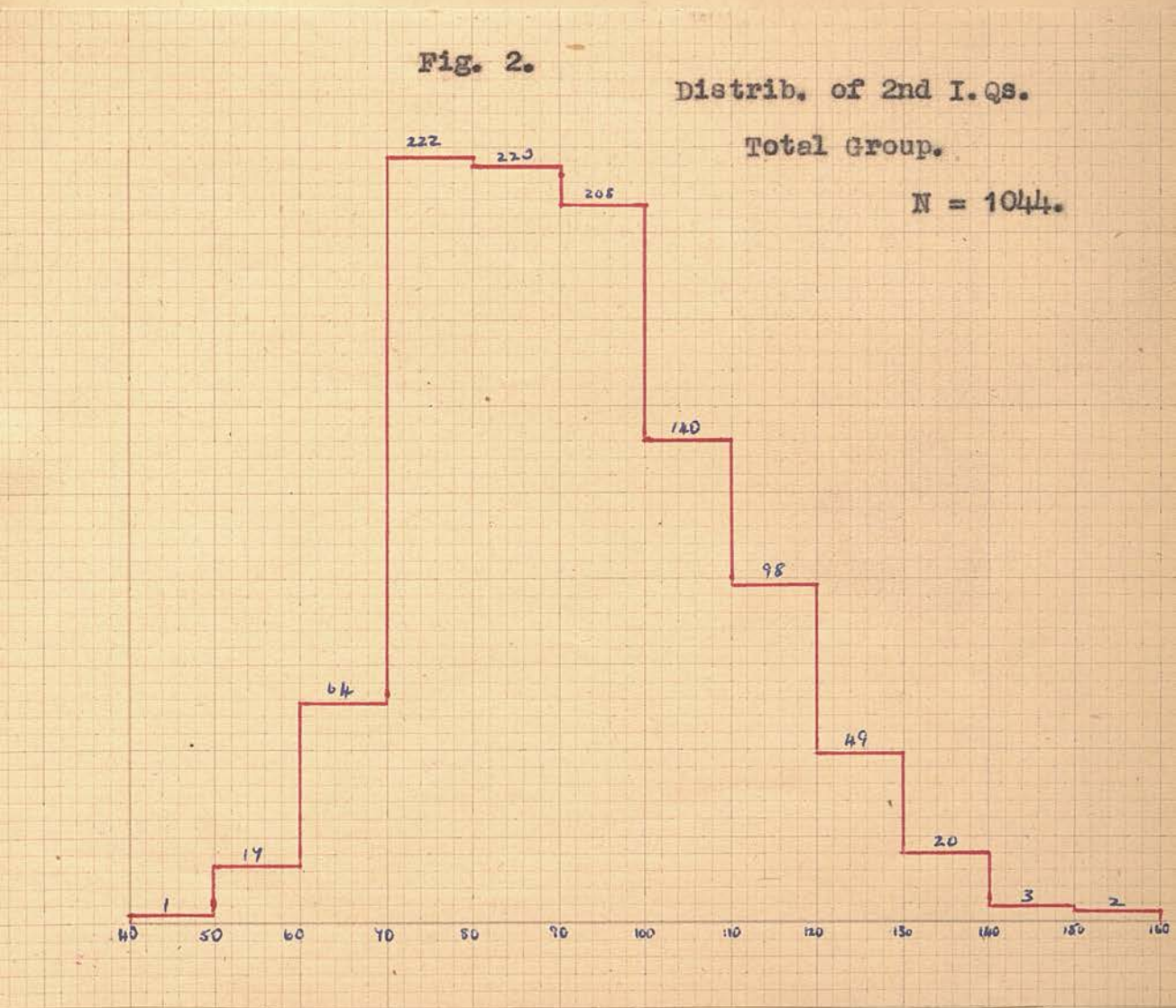



Fig. 2. Intelligence Quotients : Total Group.

The distribution of intelligence for boys and girls separately is shown in Fig. 3, plotted in terms of percentages at each 10 point interval of I.Q. and on the same axis for comparison.

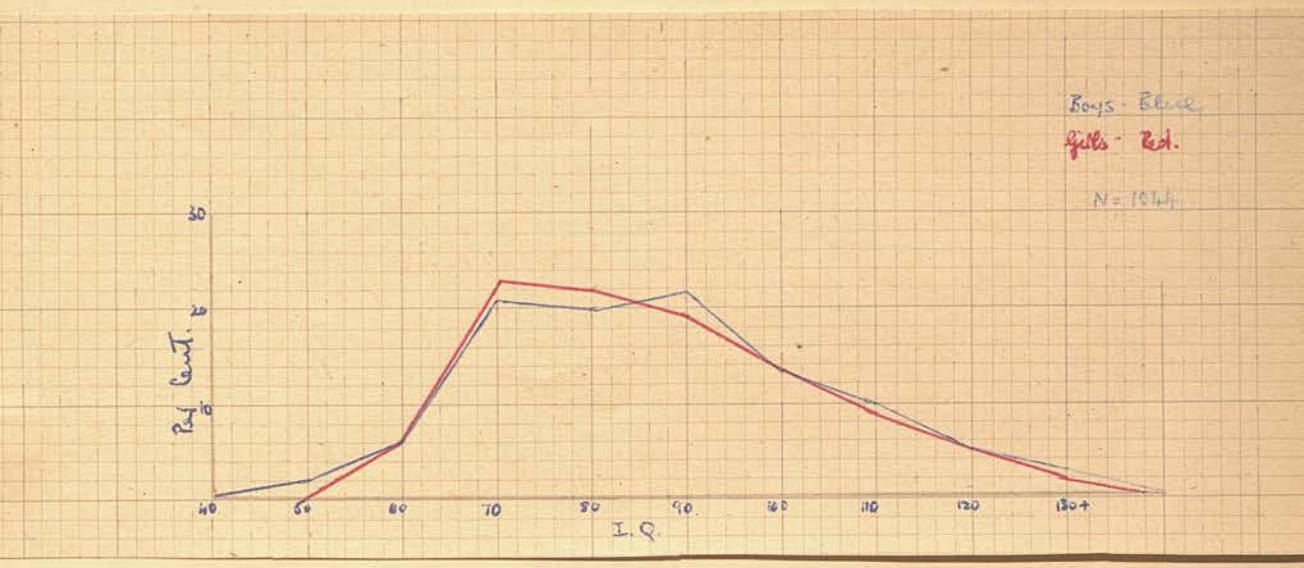



Fig. 3. Intelligence Quotients. Boys v. Girls.

The Mean I.Q. for the Total Group for 1st I.Q. and 2nd I.Q., is:

| | 1st I.Q. | 2nd I.Q. |
|---|---|---|
| Mean | 90.86 ± 1.08 | 91.22 ± 1.08 |
| S.D. | 17.84 | 17.79 |

The limits given with the Means throughout are the 5% confidence limits, i.e. the probability is .95 that the true mean lies within the limits obtained.

The Mean I.Q. for Boys alone and Girls alone on 1st and 2nd I.Q. is:

| | 1st I.Q. | | 2nd I.Q. | |
|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. |
| Boys | 91.56 ± 1.48 | 18.47 | 91.48 ± 1.46 | 18.20 |
| Girls | 89.92 ± 1.57 | 16.93 | 90.88 ± 1.60 | 17.23 |

The difference between the Means is not significant.

t - test results for Total Boys with Girls are:

t - values.

1st I.Q. 1.47 2nd I.Q. .54

In Table I, categories of intelligence for 2nd I.Q. are shown with percentages found in the different categories, for the Total Group and separately for Boys and for Girls.

Table I.

Percentages of Total Group in different Categories of Intelligence.

| I.Q. | Boys | Girls | All | Category |
|---|---|---|---|---|
| 130 plus | 2.50 | 2.22 | 2.39 | Very superior. |
| 120 - 129 | 4.86 | 4.46 | 4.69 | Superior |
| 110 - 119 | 9.73 | 8.92 | 9.38 | High Average |
| 100 - 109 | 13.08 | 13.83 | 13.40 ) | Normal or Average |
| 90 - 99 | 21.14 | 18.30 | 19.92 ) | |
| 80 - 89 | 19.96 | 22.54 | 21.07 | High Grade Dull to Low Average |
| 70 - 79 | 20.13 | 22.76 | 21.26 | Low Grade Dull |
| 60 - 69 | 6.20 | 6.02 | 6.13 | Borderline Defective |
| Below 60 | 2.34 | .89 | 1.72 | Mentally Defective |
| N | 596 | 448 | 1044 | |
| Mean 2nd I.Q. | 91.48 | 90.88 | 91.22 | |
| 1.960 $\sigma_M$ | 1.46 | 1.60 | 1.08 | |
| $\sigma$ I.Q. | 18.20 | 17.23 | 17.79 | |

The aspects of this intelligence result of particular interest are:

The wide range of capacity among the Total Group - 46 I.Q. to 155 I.Q. centred about a mean I.Q. of 91.22 (± 1.08). The very considerable proportion of this group who are of average and above average intelligence. Some 50% boys and girls who show I.Q. of 90 and above 90. Of the Boys' Group 51.31% are of at least normal intelligence, while in the Girls' Group 47.73% are girls of this intelligence level. Where intelligence is below average - that is, where I.Q. is below 90, we find among the girls 52.21% and among the boys 48.63%.

Slightly more girls than boys appear to be below average in intelligence but the difference is not significant.

Low capacity while contributing in a degree to sub-normal educational attainment by the children, is offering only a partial solution.

In 'The Intelligence of a Representative Group of Scottish Children' by A.M. McKeekan, 1937 (60), the mean intelligence quotient found for a total sample of 1000 children individually tested was 100.11 ($\sigma M$ = .53), with no significant difference found between the Mean of the Boys and the Mean of the Girls. In this present study the mean approximates to low average with the resultant quotient reflecting the selection of the groups, as the Retarded Group was specifically chosen because of

backwardness. The evidence of our data points to equality of mean intelligence for boys and girls.

The 1937 Survey showed the results for boys appeared to be consistently more 'scattered' in intelligence than for girls. This conclusion appears to be substantiated in the results found here. In the 1932 Scottish Mental Survey (98) the same finding was made of apparent equality in mean intelligence but of a slightly greater 'scatter' of intelligence for boys than for girls. The 1932 Survey report suggests 17 points of I.Q. scale as a 'best' standard deviation from the data for boys, 16 for girls. In the 1937 Survey, McMeekan finds rather 16 points for boys and 15 girls. In this survey of 1044 children the standard deviations suggest 18 for boys and 17 for girls.

Considering the percentages at different levels of intelligence some 2.39% children were found in the 'very superior' class, 2.50% boys and 2.22% girls. This figure is smaller than the percentages found in the 1937 Individual Testing when 4.7% children were found - 5.4% boys and 3.9% girls. The 1932 Binet Thousand shows a percentage of 6.1% in this class for all children. The nature of the sampling accounts for the much lower estimate found with the present group as this total distribution has been weighted at the lower end of the scale by the heavy preponderance of dull children. Nevertheless if as McMeekan suggests in the 1937 Survey that the 'best'

percentage for children of very superior intelligence, will lie between 2.5 and 6.8 per cent it is interesting that in this group the total percentage is 2.39% for all children with 2.50% for boys.

At the lowermost end of the scale the percentage found for mental deficiency is always important. Sampling errors limit the conclusions but it is likewise important to note the ambiguities attaching to the term 'mentally deficient'. Dr. Maud Merrill in the Journal of Educational Psychology 1938 draws attention to this. If low intelligence alone is described without implication of the presence of behaviour traits, then smaller percentages may follow. If a wider view is taken and low intelligence coupled with psycho-social maladjustment is considered indicative of mental defect, then the percentages will probably be higher. This was found in the investigation of Dr. E.O. Lewis (55), where he found an incidence of mental defect of 2.90 per 100 children. An incidence higher for boys than for girls. The suggested 'best' figure for Scottish Children was 2.39 per 100 children but this figure was based only on cases below 70 I.Q., whereas Lewis included a wider margin of cases.

In the present total group the demarcation line has been taken at 60 I.Q. with children 60 - 69 classified as Borderline Defective. The total percentage for all children below 60 is 1.72% - 2.34% for boys and .89% for

girls. The majority of the Total Group comprise Retarded children while the Twin Group is also a selected group. The higher percentage for boys however, bears out the contention that the incidence of defect is greater among boys than girls (Report of the Advisory Council on Education in Scotland 1951).

If 70 I.Q. is chosen as the line of demarcation between Defective and Non-Defective then the percentages in the Boys and Girls groups are 7.85% for all children with 8.34% boys and 6.91% girls.

The estimated incidences found are 1.6 to 1.8 per cent for towns and 3 per cent + for rural areas according to F.J. Schonell 1949 (90). When consideration is given to the lower line of demarcation 60 I.Q., the percentages for our Total Group are high but reflect the selection of our major group which is one of Retarded children. These high percentages are therefore not unexpected.

An estimation of the 'dullness' inherent in our group will likewise vary according to the upper limit taken and the standard deviation of the test employed. Where the upper limit is I.Q. 90 then an estimation has been made by Schonell of between 20 and 24%. Taking an upper limit of 85 I.Q. Burt considers the percentage of dull children for the country to approximate to 12 - 14%.

Considering this total group of 1044 children with an upper limit of 90 I.Q. for dullness and a lower limit of

70 it can be seen that percentages are again high - 42.33% of all children enter this category of dull. In the Boys Group 40.09%: in the Girls Group 45.30%.

There appear to be more dull girls as compared with boys, while in the extreme case of dullness, extending to defect, there are more boys than girls in this total group.

As stated in a former section, each child was individually tested twice: firstly with the Terman-Merrill L Test and then after a period of 6 months to 2 years, retested with the Terman-Merrill M, the parallel form of the same test. The mean I.Q. was calculated for each testing, for all the children and for boys and girls separately. A slight rise in Mean I.Q. for the Total Group is evident: Mean on 1st testing being 90.86 and Mean on second testing being 91.22.

The Boys alone show little change while the Girls show a slight rise in 2nd testing: Mean of 1st I.Q. being 89.92 while Mean 2nd I.Q. is 90.88 for the Girls.

Investigations mainly with Group Tests have shown that a mean practice effect of up to five points of I.Q. may be obtained when one verbal intelligence test follows a few weeks after a similar test. (See P.E. Vernon 1938 (105), D.M. McIntosh 1944 (59), D.C. Adkins 1937 (2), E.A. Peel 1951 (78)).

Practice effect appears to improve with the initial level of intelligence, reaches a maximum effect about 120 - 130

I.Q. and then appears to diminish. A differential practice effect thus appears to characterise group retestings with this significant trend. It would be dangerous to generalise from Group to Individual testing as different factors are obviously operating, but this slight rise in I.Q. might be due to the influence of what has been called 'Test Sophistication'. The children on 2nd testing were familiar with the procedure and good rapport ensured that a nervous child was not handicapped by speed or that the fears of the anxious child could be allayed and maximum co-operation assured. The Girls as a group tended to react to individual testing in this way possibly more than the boys.

Correlation of 1st with 2nd Intelligence Tests.

The Correlation of the 1st I.Q. with 2nd I.Q. was calculated for the Total Group N = 1044 and r = .878. Terman (97) computed the Correlation of Form L against Form M for the twenty-one age groups in his test and found Correlations ranging from .85 to .95 with a median of .91.

The Correlation is thus sufficiently significant to weight the testings as reliable.

For the Table presenting the Scattergram of the Total Group, plotting 1st Intelligence Test with 2nd Intelligence Test, see Appendix B, Table I.

## The Relation of Attainment to Capacity.

The relation of attainment to capacity was estimated for the Total Group of 1044.

Fig. 4 shows the distribution of the 2nd Accomplishment Quotients for Reading and Spelling combined for all the children, including 120 whose A.Qs. were above 100.

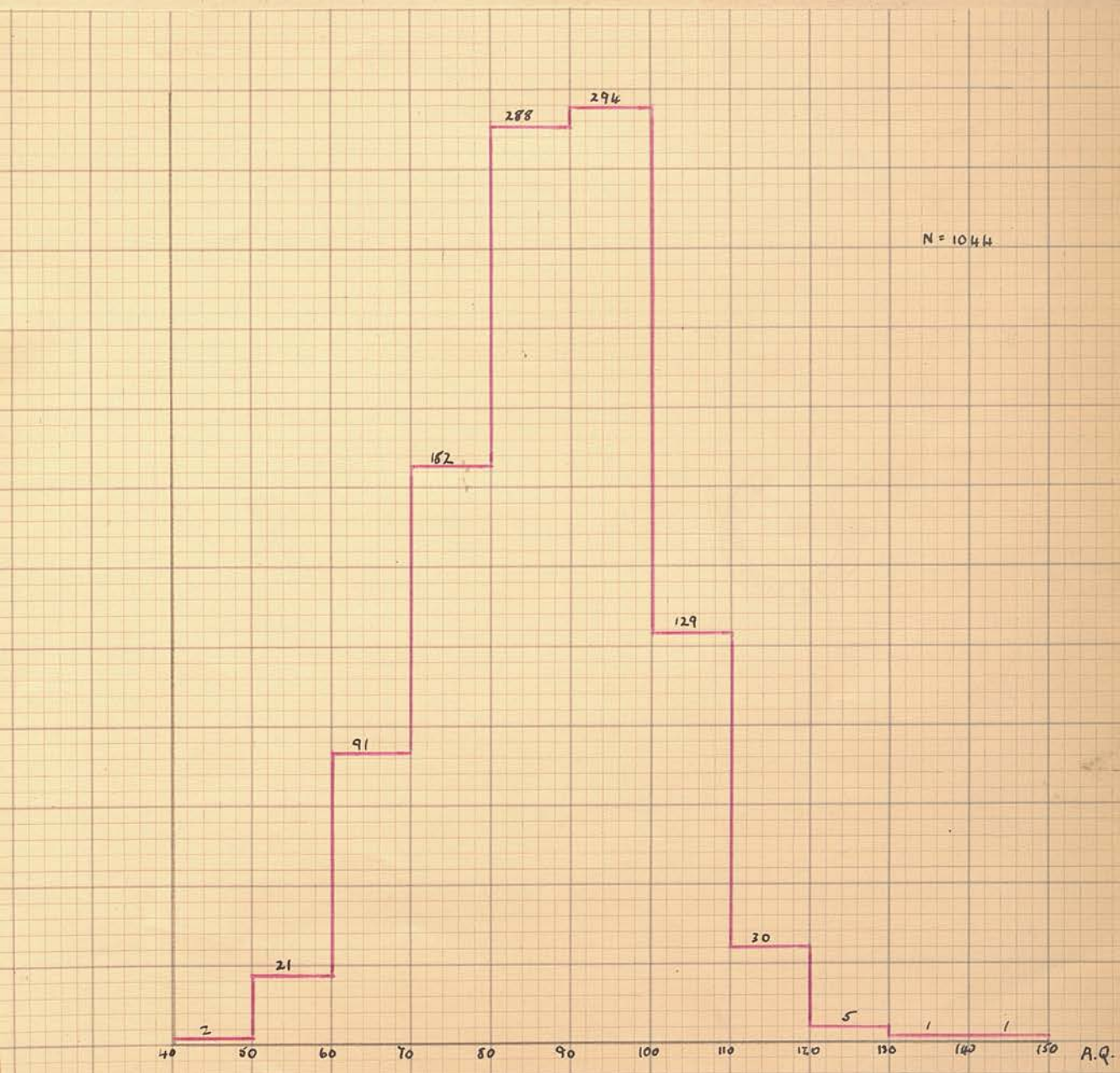



Fig. 4. Accomplishment Quotients : Total Group.

The Mean A.Q. for the Total Group for 1st and 2nd A.Q. is:

| | 1st A.Q. | 2nd A.Q. |
|---|---|---|
| Mean | 87.33 ± .83 | 86.77 ± .83 |
| S.D. | 13.71 | 13.65 |

The Accomplishment Quotients indicate the extent to which the children are working to capacity in the two activities combined. A wide range of accomplishment centres about a Mean of 86.77. On the average then, these children are working to 87% only of their capacity.

The Mean A.Q. for Boys and Girls alone on 1st and 2nd A.Q. is:

| | 1st A.Q. | | 2nd A.Q. | |
|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. |
| Boys | 84.35 ± 1.05 | 13.12 | 83.83 ± 1.10 | 13.67 |
| Girls | 91.29 ± 1.25 | 13.49 | 90.68 ± 1.17 | 12.62 |

Considering only the A.Qs. there are important differences between the boys and girls which are basically sex determined. These differences can be observed in Figs. 5 and 6 which present the A.Qs. for boys and girls from two aspects.

Fig. 5 gives the total 2nd A.Q. distribution for Boys and Girls separately in terms of percentages at different levels of A.Q. Fig. 6 shows A.Qs. below 100 for the 2nd Testing in terms of percentages below certain limits of A.Q. Fig. 6 therefore, brings out the incidence of learning interference in these retarded boys and girls, as 100 A.Q. is synonymous with work at capacity.

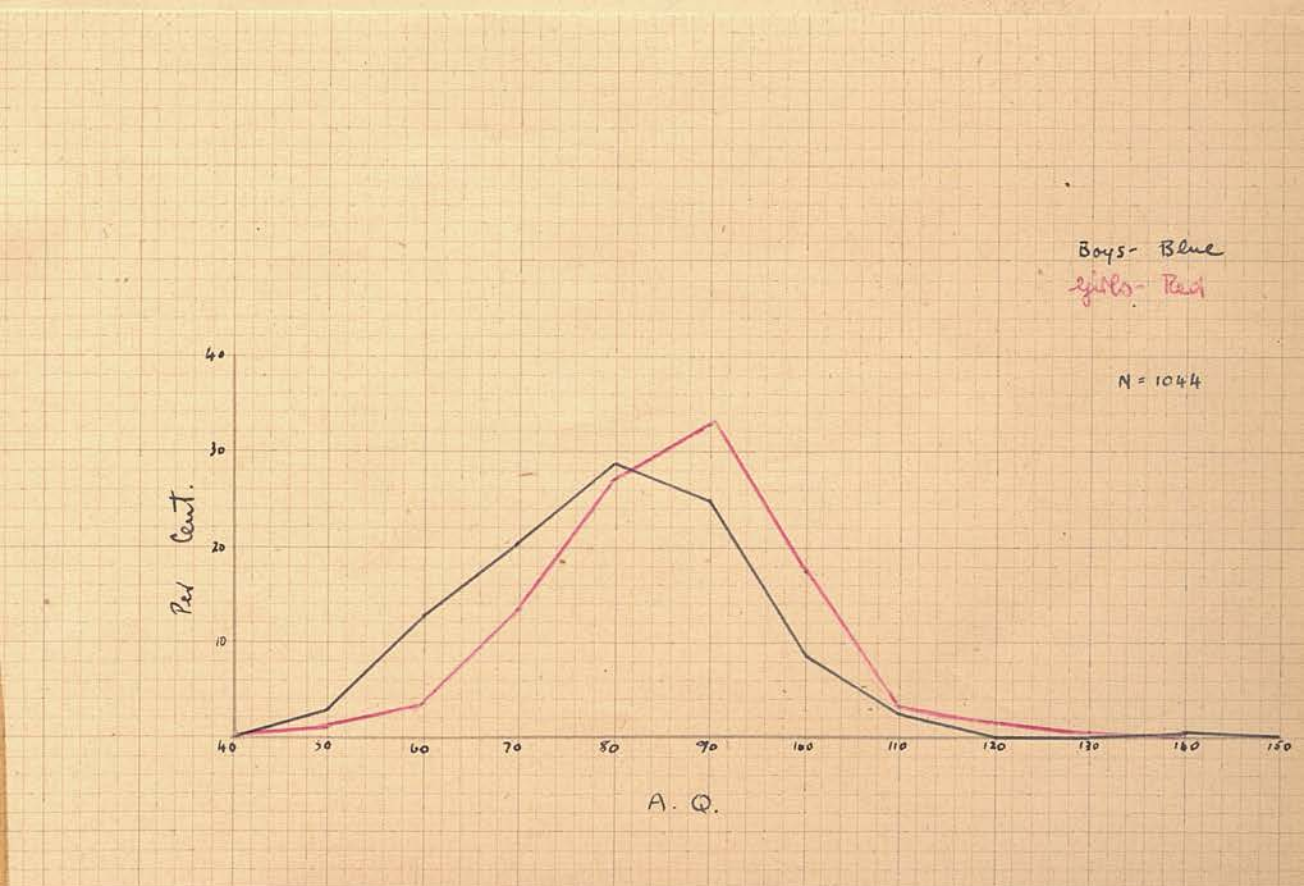



Fig. 5. Accomplishment Quotients.

Percentages of Boys and Girls at different levels of A.Q.

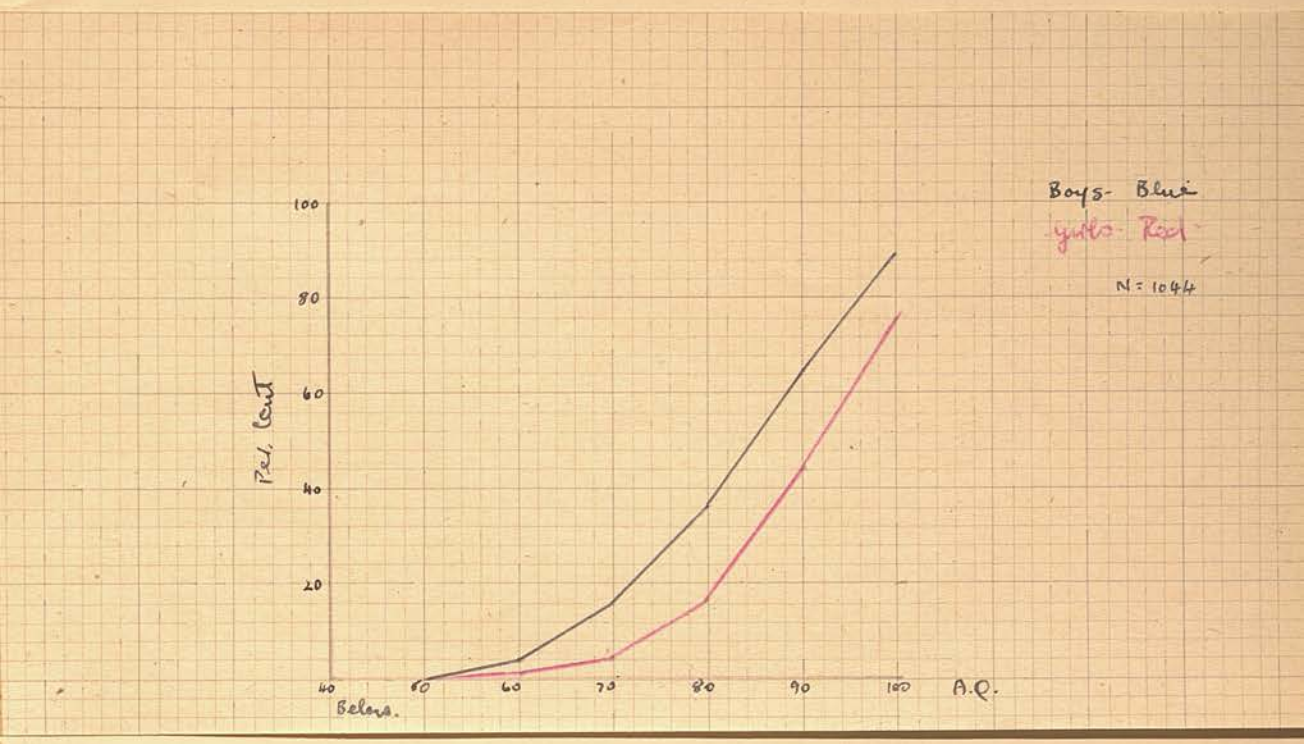



Fig. 6. Percentages of Boys and Girls below certain levels of A.Q.

Comparing the difference between the Means for Boys with Girls for the total group,

t - test results on Achievement are:

1st A.Q. 8.35

2nd A.Q. 8.29

Setting up the null hypothesis, on achievement the results indicate that the probability is less than .001 or 1 in 1000 that the value observed could be obtained on the null hypothesis or that the value is a chance difference, and thus we may conclude that the boys definitely differ from the girls and are poorer in

performance. The sex difference is in line with the general finding of investigators that language disability is 'sex-influenced'.

Tables 2 and 3 present the data on which Figs. 5 and 6 are based.

Table 2.

Combined Reading and Spelling Accomplishment.

Percentages at Different Levels of A.Q. (2nd A.Q.)

| A.Q. | Boys | Girls | All |
|---|---|---|---|
| 140-149 | .167 | | .09 |
| 130-139 | 0.00 | .223 | .09 |
| 120-129 | 0.00 | 1.11 | .47 |
| 110-119 | 2.18 | 3.79 | 2.87 |
| 100-109 | 8.55 | 17.85 | 12.54 |
| 90- 99 | 24.66 | 32.14 | 27.87 |
| 80- 89 | 28.02 | 27.00 | 27.58 |
| 70 -79 | 20.30 | 13.61 | 17.43 |
| 60- 69 | 12.91 | 3.12 | 8.83 |
| 50- 59 | 3.02 | .669 | 2.01 |
| 40- 49 | .167 | .223 | .19 |
| N: | 596 | 448 | 1044 |
| Mean A.Q. | 83.83 ± 1.10 | 90.68 ± 1.17 | 86.77 ± .83 |
| S.D. of A.Q. | 13.67 | 12.62 | 13.65 |

Table 3.

Combined Reading and Spelling Accomplishment.

Percentages below certain limits of A.Q.

| Below A.Q. | Reading and Spelling | | |
|---|---|---|---|
| | Boys | Girls | All |
| 150 | 100 | | 100.00 |
| 140 | 100 | 100 | 99.90 |
| 130 | 99.83 | 99.77 | 99.8 |
| 120 | 99.83 | 98.66 | 99.32 |
| 110 | 97.65 | 94.86 | 96.45 |
| 100 | 89.09 | 77.45 | 83.90 |
| 90 | 64.42 | 44.64 | 56.03 |
| 80 | 36.40 | 17.63 | 28.44 |
| 70 | 16.10 | 4.01 | 11.01 |
| 60 | 3.18 | .89 | 2.20 |
| 50 | .167 | .22 | .19 |
| N: | 596 | 448 | 1044 |
| Mean A.Q. | 83.83 ± 1.10 | 90.68 ± 1.17 | 86.77 ± .83 |
| S.D. of A.Q. | 13.67 | 12.62 | 13.65 |

At all levels of A.Q. below 100 we find consistently higher percentages of boys than girls indicating higher incidence in boys than in girls of learning interference due to other factors than low capacity.

Backwardness with the Total Group was calculated for Reading accuracy only and in Spelling, the two results being then combined to form an Accomplishment Quotient. A total picture of Retardation in Reading would involve tests of speed, comprehension, composition, etc., but these were omitted partly because the mental ages of many children were such that understanding of simple words was difficult and the children at the lower end of the intelligence scale were incapable of achievement on written tests; partly also as an investigation of retardation was subsidiary to the main study of the laterality of the groups.

While, as with intelligence, the obtained percentages seem high they reflect the selection of the groups, the Retarded Group being specifically chosen because of backwardness, apart from innate dullness. Estimates of general backwardness in the basic subjects, including all pupils, i.e. dull and backward, as well as merely backward yield figures ranging from 13-14% in certain subjects to as high as 23.5% for backwardness in English (F.J. Schonell 1949 (90)). Schonell thinks that figures for general backwardness throughout the country may be as high as 20% while for specific backwardness, i.e. in one or more subjects with pupils of average or above average intelligence, the percentage approximates to 4 - 6%. If the two types of cases are added together then 24 - 25% of pupils require some kind of particular help of a partial

or total kind, for a long or limited period.

In the Total Group of 1044 children, 56.03% or slightly more than half of the group are working below potential.

In the Boys Group 64.42% are not working to capacity while 44.64% in the Girls Group are below capacity.

The boys are significantly poorer than the girls.

An interesting feature of the Mean levels of attainment on 1st A.Q. and 2nd A.Q. is the apparent slight decrease in 2nd A.Q. for all children and for Boys and Girls separately. This may reflect the influence of increasing age. The retardation of children becomes more evident as they grow older and disability is frequently accompanied by negative attitudes and sense of failure. Thus progress is further hindered with a consequent loss in achievement which emerges possibly in lower A.Q. results.

In relating language accomplishment to intelligence a clear picture can be seen by plotting I.Q. with A.Q. and then sub-dividing the Grid to separate the children of at least 'below average' intelligence, i.e. I.Q. less than 90 - from those who are average and above average intelligence, i.e. I.Q. 90 and above. Likewise, a horizontal line of division will give two accomplishment groups - those children of A.Q. 100 and above and those of A.Q. less than 100. This is illustrated by the following diagram:-

| | Below 90 I.Q. | Above |
|---|---|---|
| Above 100 A.Q. | A | C |
| Below | B | D |

The following categories can then be seen:-

A plus B: Where Intelligence is 'below average' and associated with a total range of A.Q.

A : Retardation explicable in terms of low capacity alone, (i.e. I.Q. less 90, A.Q. 100 or above).

B : Retardation due to a combination of low capacity and learning interference, (I.Q. less 90, A.Q. below 100).

C plus D: Intelligence average or above average and associated with a total range of A.Q.

C : No educational problem. (I.Q. is above 90 and A.Q. 100 or above).

D. : Retardation due entirely to learning interference outwith capacity. (I.Q. is 90 or above and A.Q. is less 100)

B Plus D: Where attainment is below average and associated with a total range of I.Q.

Table 4 presents the percentages of the Total Group in these categories.

Table 4.

Reading and Spelling combined:

Categories of Accomplishment and Intelligence.

Percentages.

| Category | Boys | Girls | All |
|---|---|---|---|
| A + B | 48.65 | 52.22 | 50.19 |
| A | 5.03 | 13.39 | 8.62 |
| B | 43.62 | 38.83 | 41.57 |
| C + D | 51.33 | 47.76 | 49.81 |
| C | 5.87 | 9.15 | 7.27 |
| D | 45.46 | 38.61 | 42.54 |
| B + D | 89.08 | 77.44 | 84.11 |

In these incidences the essentials of the Achievement to Intelligence relationship can be seen.

Interesting points are:-

C - The very small percentage 7.27 of the Total Group who show no educational problem. In this category a higher percentage of girls than boys is apparent.

A - The small proportion where learning interference can be explained in terms of low intelligence - 8.62%

B - Where low capacity combined with learning interference produce the retardation, 41.57%.

D - The high percentage of children of average, or above average who are working below capacity, 42.54%, where retardation would appear to be due to factors of learning interference outwith capacity. A higher percentage of boys to girls is present.

B plus D - The very considerable proportion of the Group who show learning interference apart from capacity, 84.11%.

When Intelligence is equated out, these percentages represent the total effect of the operation of factors of language interference and are therefore of interest in relation to the influence which Laterality may be exerting as a factor of language interference.

In the Total Group, 89.08% of the Boys and 77.44% of the Girls are working below capacity in Reading and Spelling combined.

Correlation Ratio: I.Q. with A.Q.

The Correlation Ratio of the Total Group 1044 relating Achievement to Intelligence (2nd I.Q. 2nd A.Q.) was calculated for all the children and separately for Boys alone and for Girls alone. The Scattergram for the Total Group can be found in Appendix B, Table 2.

The correlation ratios for the Total Group and Boys Group were not significant.

r = .023 for the Total Group (Girls + Boys).

r = -.227 for Girls Alone.

r = .080 for Boys Alone.

The correlation for all the Girls taken alone in the Total Group is significant. The negative association between I.Q. and A.Q. indicating that the Achievement decreases as the I.Q. increases. Hence the girls who are most intelligent are not working as hard as those of a lower I.Q. level, or the difference between potentiality and actual achievement appears greatest with the clever girls. There is little association between the intelligence level of the boys and their achievement. As the boys are significantly poorer than the girls in achievement this may mean that both clever and dull boys are doing equally badly as compared with the girls. Further, since no significance emerges with intelligence and achievement for the boys, one must look for factors extraneous to capacity to explain their poor achievement. The question of their Laterality therefore becomes important as a possible significant factor in the situation.

Summarising the findings for the Total Group:

The Intelligence level of the Total Group of children approximates to the average, there being no significant difference between the Boys and Girls.

In Achievement however, the Boys are significantly poorer than the Girls while the Group as a whole are working only to 87% of their capacity.

A high incidence of language disability is present.

Only some 7% of the Total Group show no problem, in that intelligence is average or above average and achievement is above 100.

Factors extraneous to capacity must therefore be looked for, to explain the major part of retardation, particularly with the Boys. There is considerable impress of learning interference, 84.11% of the children being affected in varying degree, associated with a wide range of capacity. Of these children, a significantly greater proportion are boys, the majority of whom are of average and above average intelligence.

The relationship of Achievement to Intelligence is more marked with the Girls, indicating that the Girls of higher intelligence are working at lower level compared with Girls not so clever.

## References.


60. McMeekan A.M. - 1937. The Intelligence of a Representative Group of Scottish Children. Pub. by Scottish Council for Research in Education.

98. McMeekan A.M. - 1932. The Intelligence of Scottish Children. Univ. London Press. Pub. by Scottish Council for Research in Education.

55. Lewis E.O. - 1925 - 27. Report of the Mental Deficiency Committee, Part IV. Report on an Investigation into the incidence of Mental Deficiency in Six Areas 1925 - 27. London, H.M. Stationery Office, 1929.

90. Schonell F.J. - 1949. Development of Educational Research. British Journal Educ. Psychology, Vol. XIX, Part II, 1949.

1. 1951. Pupils with Mental or Educational Disabilities. Report of the Advisory Council on Education in Scotland. H.M. Stationery Office, Edinburgh 1951.

11. Burt C. - The Backward Child. P.S. King & Son. Univ. London Press.

105. Vernon P.E. - 1938. Intelligence Test Sophistication. Journal of Educ. Psychology. Vol. VIII 1938.

59. McIntosh D.M. - 1944. The Effect of Practice in Intelligence Tests. Journal of Educ. Psychology Vol. XIV 1944.

2. Adkins D.C. - 1937. The Effect of Practice on Intelligence Test Scores. Journal Educ. Psychology Vol. XXVIII 1937.

78. Peel E.A. - 1951. A Note on Practice Effects in Intelligence Tests. Journal Educ. Psychology. June 1951.

97. Terman L.M. and Merrill M.A. - 1937. Measuring Intelligence. Harrap & Co. 1937.

50. Jones M.C. - The Development of Early Behaviour Patterns in Young Children. J. Genet. Psych. 1926 - 33.

36. Haefner R. - The Educational Significance of Lefthandedness. Teach. Coll. Cont. to Educat. 1929.

## Chapter 3(a) - Analysis of Normal Group.

Having defined in the previous chapter the general characters of the retardation situation of the Total Group of children, further analysis has been made in the next three chapters of the respective subgroups, viz., Normal, Retarded and Twin. The relationship of their Attainment to Capacity was examined in order to assess any marked differences among the respective groups.

The Control Group were designated Normal as they were not included because of specific referral for retardation but matched a member of the Retarded Group in age, sex and school. As a group they may or may not be retarded. Analysis will clarify this point.

As chosen they numbered 200 children but 20 of these children were untraced or had left the County at the time of the second testing. They were therefore omitted, leaving 180 children, 100 boys and 80 girls who were examined twice.

As previously indicated in so far as the Accomplishment Quotient fell below 100, was their evidence of work below capacity. It was found that 34 of the Normal Group were not retarded in that the A.Q. was over 100. The tables and figures following show calculations based on the total number (180) in the group in order to obtain a general picture.

### Level of Intelligence

The distribution of intelligence has been plotted for

boys and girls separately in terms of percentages at each 10 point interval of I.Q. and on the same axis for comparison. The levels of each can thus be more clearly visualised. Fig. 7 presents the data.

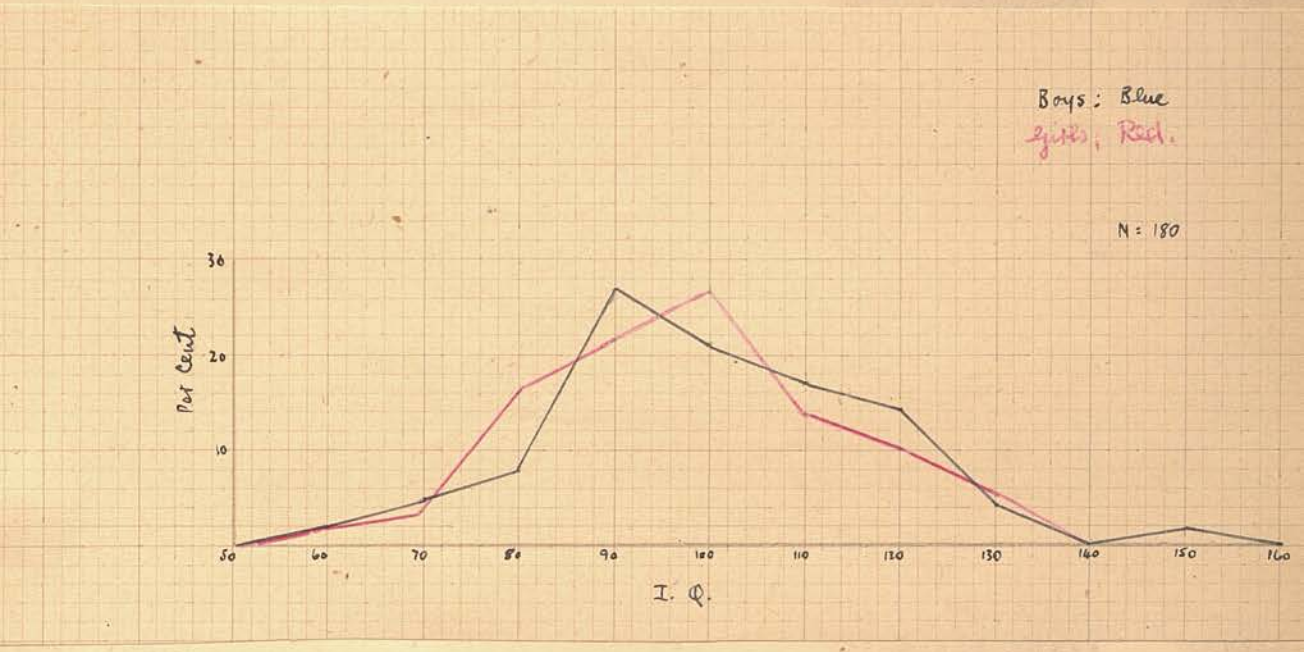



Fig. 7: Intelligence Quotients: Boys v Girls.

The Mean I.Q. for the Normal Group - Boys and Girls - for 1st I.Q. and 2nd I.Q. is -

| | 1st I.Q. | 2nd I.Q. |
|---|---|---|
| Mean | 101.33 ± 2.94 | 102.56 ± 2.49 |
| S.D. | 20.15 | 17.05 |

The Mean I.Q. for Boys alone and Girls alone of 1st and 2nd I.Q. is -

| | 1st I.Q. | | 2nd I.Q. | |
|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. |
| Boys | 104.70 ± 4.22 | 21.51 | 103.60 ± 3.38 | 17.24 |
| Girls | 97.12 ± 3.85 | 17.56 | 101.25 ± 3.69 | 16.82 |

The difference between the means is significant at the .05 level on the 1st testing - t - test result = 2.54 for 1st I.Q. indicating that the boys are superior to the girls in Intelligence.

As the second testing only is being considered the t - test result on 2nd I.Q. = .92. The difference therefore is not significant and indicates that as a group the boys and girls are of similar level of intelligence at a grading slightly above average.

With individual testing the results shown in The Trend of Scottish Intelligence (99) indicate an I.Q. significantly superior to 100 for all pupils, with the boys' mean I.Q. being significantly superior to that of girls (see Chapter IV by D. Kennedy-Fraser). This was found on the first testing when the Terman-Merrill L was given but the boys were not found to be superior to the girls on retest when the Terman-Merrill M was administered. A noticeable rise in 2nd I.Q. is apparent with girls on retesting.

The typical mean intelligence quotient for this group would appear to be above 100. The typical intelligence quotient for boys and girls on individual testing in the 1937 Survey approximated to 100. This was also in agreement with the finding of the 1932 Scottish Mental Survey (98). The rise in points of I.Q. may be due to the rise in relation to practice effect. Sampling errors may also be operating.

as this Normal Sample, while not referred for retardation, were related to the Retarded Group in that they were paired and drawn from the same schools.

In Table 5 categories of intelligence for 2nd I.Q. are shown with the percentages found in the different categories, for the Normal Group and separately for Boys and for Girls.

Table 5.

Percentages of Normal Group

in different categories of Intelligence.

| I.Q. | Boys | Girls | All | Category |
|---|---|---|---|---|
| 130 + | 5.00 | 5.00 | 5.00 | Very superior |
| 120-129 | 14.00 | 10.00 | 12.22 | Superior |
| 110-119 | 17.00 | 13.75 | 15.55 | High average |
| 100-109 | 21.00 | 26.25 | 23.33 | Normal or average |
| 90- 99 | 27.00 | 21.25 | 24.44 | Normal or average |
| 80- 89 | 8.00 | 16.25 | 11.72 | High grade dull to low average |
| 70- 79 | 5.00 | 3.75 | 4.44 | Low grade dull |
| 60- 69 | 2.00 | 2.5 | 2.22 | Borderline defective |
| Below 60 | 1.00 | 1.25 | 1.11 | Mentally defective |

| | | | |
|---|---|---|---|
| N | 100 | 80 | 180 |
| Mean 2nd I.Q. | 103.60 | 101.25 | 102.56 |
| 1.960 $\sigma$ M | 3.38 | 3.69 | 2.49 |
| S.D. of I.Q. | 17.24 | 16.82 | 17.05 |

Among this group in capacity a wide range is evident 50 to 154 I.Q. centred about a mean I.Q. of 102.56. $\pm$ 2.49.

Of interest is the very considerable proportion of the group who are of average or above average intelligence. Some 80.54% show I.Q. of 90 or above 90: 84.00% of the Boys group are boys with normal intelligence while 76.25% are girls of this intelligence level.

Where intelligence is below average, i.e. where I.Q. is below 90, we find 23.75% girls and 16% boys.

The difference between the levels of the boys and girls is not significant. Low capacity thus, while contributing in some degree to subnormal educational achievement with these children is offering only a partial solution.

In comparing the percentage of children in this Normal Group with the individual testing of 1937 and 1932 samples, we find at the topmost end of the scale above 129 I.Q. 4.7% in 1937 Individual Testing and 6.1% in 1932 Binet Thousand. In this sample 5% for all the children were found to be above 129 I.Q. there being equal percentages of Boys and Girls, i.e. 5% Boys and 5% Girls. At the lowermost end of the scale taking Below 70 I.Q. as the limit of demarcation for Deficiency, the percentage in this Normal Group is 3.33% for all children with 3% in the Boys Group and 3.75% in the Girls Group. With the 1937 Individual Testing 1.3% was found below 70 I.Q. .7% Boys and 1.9% Girls.

The 1932 Binet Thousand showed .6% for all children with .6% for Boys and .6% for Girls. There would

therefore appear to be a high number of borderline defective cases in this present group, if not actual defectives.

The smallness of the present group however and the consequent sampling error involved, limit the definiteness with which conclusions may be stated.

Correlation of 1st and 2nd Test.

The Correlation Ratio for the Normal Group was calculated plotting 1st Intelligence Test (Terman-Merrill L) with 2nd Intelligence Test (Terman-Merrill M).

The correlation ratio r = .795 is significant at the .001 level and thus weights the testings as reliable. There is therefore close association between the results obtained in testing on the two occasions.

The Relation of Attainment to Capacity.

The relation of Attainment to Capacity was estimated for the Total Normal Group N = 180.

The Mean Accomplishment Quotient was calculated for the Total Group and for Boys and Girls as follows.

The Mean A.Q. for the Total Normal Group for 1st and 2nd A.Q. is -

| | 1st A.Q. | 2nd A.Q. |
|---|---|---|
| Mean | 92.89 ± 2.02 | 91.22 ± 1.64 |
| S.D. | 13.83 | 11.23 |

A wide range of Accomplishment centres about a mean of 91.22 (for 2nd A.Q.). These children are therefore working to 91% of their capacity.

The mean A.Q. for Boys and Girls alone on 1st and 2nd A.Q. is -

| | 1st A.Q. | | 2nd A.Q. | |
|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. |
| Boys | 89.10 ± 2.53 | 12.90 | 89.00 ± 2.00 | 10.19 |
| Girls | 97.62 ± 2.97 | 13.56 | 94.00 ± 2.61 | 11.90 |

Considering only the A.Qs., there are important differences which are basically sex determined.

Figs. 8 and 9 make these differences clear (for 2nd A.Q.)

Fig. 8 gives the total 2nd A.Q. distribution for boys and girls separately in terms of percentages at different levels of A.Q. while Fig. 9 shows A.Qs. below 100 (for the 2nd testing) in terms of percentages below certain limits of A.Q. Fig. 9 therefore brings out the incidence of learning interference in these Normal Group boys and girls.

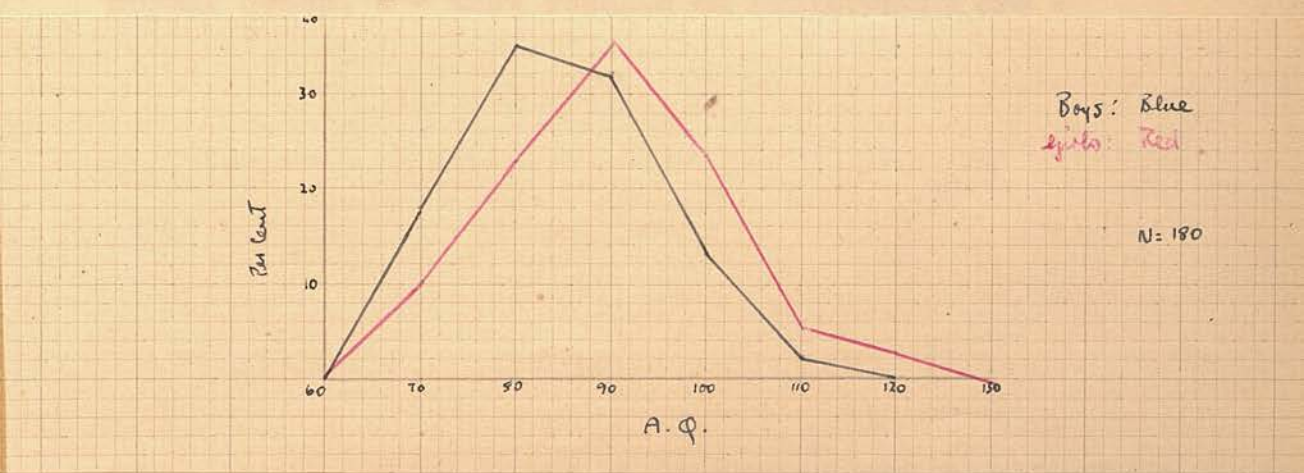



Fig. 8: Accomplishment Quotients.
Percentages of Boys and Girls
at different levels of A.Q.

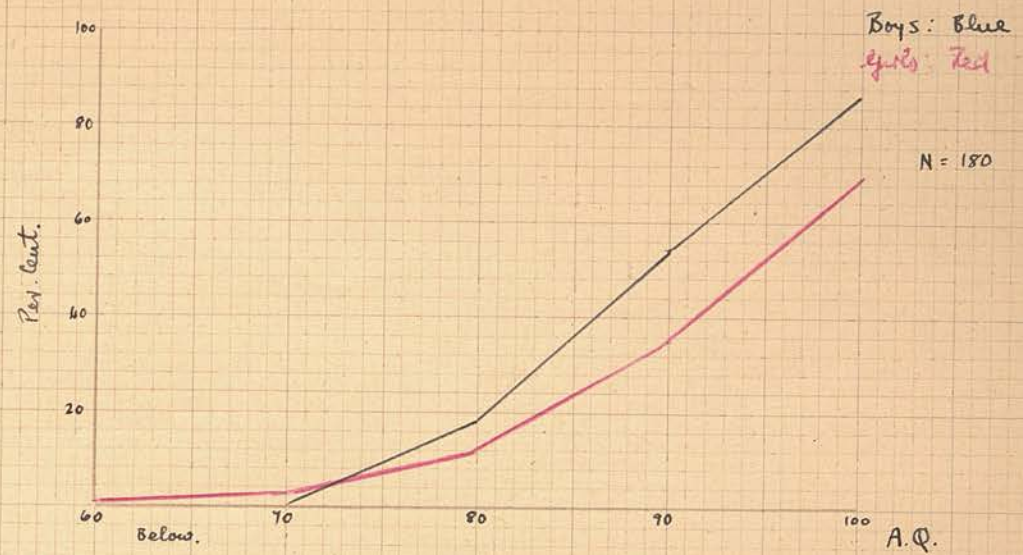



Fig. 9: Percentages of Boys and Girls below certain levels of A.Q.

Testing for Significance - Boys with Girls for the Normal Group, t - test results on Achievement are -

1st A.Q. = 4.31

2nd A.Q. = 3.04

On the 1st testing setting up the null hypothesis, the t - test yields a probability of less than .001 that the value could be obtained on the null hypothesis, hence one can infer that the boys definitely differ from the girls and are poorer in language achievement.

On the 2nd testing t - test result = 3.04 and is significant at the .01 level. One can still thus maintain the inference that the boys compared with the girls are

inferior in educational attainment in Reading and Spelling.

Certain features of the Attainment Quotients are interesting. On successive testing there is a fall in A.Q. more marked with the girls alone. The boys' result remained stationary. In the examination of the correlation ratio for the Total group of 1044 relating achievement to intelligence it was observed that the correlation for girls alone was significant and negative. It may therefore be that with this Normal group the more clever girls are falling further back in achievement than the boys. This may be related also to age in that the boys as they grow older are maintaining the same ratio of progress while the girls as they grow older are showing larger discrepancies between ability and achievement in the subject measured. The scatter in attainment is also wider with the girls S.D. 11.90 compared with S.D. of 10.19 for the boys.

Tables 6 and 7 present the data on which Figs. 8 and 9 are based.

Table 6 presents the percentages of the Accomplishment Quotients at different levels of A.Q. while Table 7 shows the percentages below certain limits of A.Q.

Table 6.

| A.Q. | Boys | Girls | All |
|---|---|---|---|
| 140 - 149 | | | |
| 130 - 139 | | | |
| 120 - 129 | | 2.5 | 1.11 |
| 110 - 119 | 2.00 | 5.00 | 3.33 |
| 100 - 109 | 13.00 | 23.75 | 17.77 |
| 90 - 99 | 32.00 | 35.00 | 33.33 |
| 80 - 89 | 35.00 | 22.50 | 29.44 |
| 70 - 79 | 18.00 | 10.00 | 14.44 |
| 60 - 69 | | 1.25 | .55 |
| 50 - 59 | | | |
| 40 - 49 | | | |

| | | | |
|---|---|---|---|
| N | 100 | 80 | 180 |
| Mean A.Q. | 89.00 | 94.00 | 91.22 |
| 1.960/ M | 2.00 | 2.61 | 1.64 |
| S.D. of A.Q. | 10.19 | 11.90 | 11.23 |

Table 7.

Combined Reading and Spelling Accomplishment.

Percentages below certain limits of A.Q.

| | Reading + Spelling | | |
|---|---|---|---|
| Below A.Q. | Boys | Girls | All |
| 150 | | | |
| 140 | | | |
| 130 | | 100 | 100 |
| 120 | 100 | 97.5 | 98.88 |
| 110 | 98 | 92.5 | 95.55 |
| 100 | 85 | 68.75 | 77.77 |
| 90 | 53 | 33.75 | 44.44 |
| 80 | 18 | 11.25 | 15.00 |
| 70 | | 1.25 | .55 |
| 60 | | | |
| 50 | | | |
| N | 100 | 80 | 180 |
| Mean A.Q. | 89.00 | 94.00 | 91.22 |
| 1.960 $\sigma$ M | 2.00 | 2.61 | 1.64 |
| S.D. of A.Q. | 10.19 | 11.90 | 11.23 |

At all levels of A.Q. below 100 we find consistently higher percentages of boys than girls, indicating higher incidence in boys than in girls of learning interference due to factors other than low capacity.

In relating language accomplishment to intelligence a clear picture can be seen, by plotting I.Q. with A.Q. and then subdividing the grid to separate children of at least 'below average' intelligence, i.e. I.Q. less than 90, from those who are average and above average intelligence, i.e. 90 and above 90. Likewise a horizontal line of division will yield two accomplishment groups - those children of A.Q. 100 and above 100 and those of A.Q. less than 100. The following diagram shows the percentages in each category.

| | Below 90 I.Q. | Above |
|---|---|---|
| Above 100 A.Q. | A. 8.33% | C. 13.88% |
| Below | B. 11.11% | D. 66.66% |

The following groups can then be seen:-

A + B 19.44% where intelligence is below average and associated with a total range of A.Q.

A 8.33% Retardation explicable in terms of low capacity alone, i.e. I.Q. less than 90, A.Q. 100 or above.

B 11.11% Retardation due to a combination of low capacity and learning interference. (I.Q. less 90 and A.Q. less 100).

C + D 80.54% Intelligence average or above average and associated with a total range of A.Q.

C 13.88%. No educational problem. (I.Q. above 90, A.Q. above 100.)

D 66.66%. Retardation due entirely to learning interference extraneous to capacity. (i.e. I.Q. is 90 or above and A.Q. less than 100).

B + D 77.77%. Where Attainment is below average associated with a total range of I.Q.

Table 8 presents the percentages of the Normal Group in these categories separately for Boys and Girls.

Table 8.

Categories of Accomplishment and Intelligence.

Percentages.

| Category | Boys | Girls | All |
|---|---|---|---|
| A + B | 16. | 23.7 | 19.44 |
| A | 3. | 15. | 8.33 |
| B | 13. | 8.7 | 11.11 |
| C + D | 84. | 76.1 | 80.54 |
| C | 12. | 16.2 | 13.88 |
| D | 72. | 59.9 | 66.66 |
| B + D | 85. | 68.6 | 77.77 |

In the above table the differences between boys and girls with reference to retardation become clear.

In these incidences the essentials of the achievement to intelligence relationship can be seen for this Normal Group.

The very small percentage in category A - 8.33% indicates that low intelligence is not operating to a major extent to cause retardation with the Normal Group.

Low intelligence would appear to be operating more strongly with the girls than boys in this category.

Conversely the very high percentage in category D - 66.66%, where retardation is due entirely to factors extraneous to capacity is important. The wide variation in percentages between boys and girls here is interesting.

The small percentage in category C - 13.88% who show no problem - a higher percentage of girls than boys show no problem, while likewise a small percentage 11.11% in B shows a number of children where retardation can be explained by low capacity and learning interference outwith capacity.

An important feature, relevant to our inquiry is the category B + D with 77.77% of children working educationally below capacity, (i.e. A.Q. less than 100) when Intelligence is equated out. They are important in the possibility they hold of factors of laterality working to the detriment of achievement in children of average and above average intelligence.

Correlation Ratios.

The association of Achievement to Intelligence level was computed for the Total Normal Group and for Boys alone and Girls alone.

For the Total Normal Group r = -.384

For Boys alone r = -.304

For Girls alone r = -.464.

These correlations are all highly significant at the .001 level and indicate for this Normal Group that as the Intelligence Quotient increases the Accomplishment Quotient decreases. Hence the suggestion is that the intelligent children are not working as hard as those of lower capability. This applies both to Boys and Girls and is more strongly indicated with the Girls.

Summarising the findings for the Normal Group.

The intelligence level of the total Normal Group is slightly above the average, there being no significant difference in 2nd I.Q. (a significant difference in favour of the boys was observable on 1st testing) between Boys and Girls.

In Achievement the boys are significantly poorer than the girls while the group as a whole is working to approximately 91% of capacity.

A high incidence of language disability is present with the Group. Only some 14% of the total group show no problem in that intelligence is average or above average and achievement is above 100.

There is very considerable impress of learning interference, approximately 78% of the children, more than three-quarters of the Group being affected in varying degree, associated with a wide range of capacity.

Of these children, a significantly greater proportion are boys, the majority of whom are of average and above average intelligence.

A very significant feature of the Group is that the clever children appear to be doing least well in achievement or are not working so hard as those of poorer mental calibre.

## References.


99. The Trend of Scottish Intelligence - Scottish Council for Research in Education. University London Press Ltd. 1949.

98. The Intelligence of Scottish Children - A National Survey of an Age Group - Published by S.C.R.E. University of London Press, November 1933.

## Chapter 3 (b)

## Analysis of Retarded Group.

The Final group for investigation and analysis numbered 520. This group was gathered from cases which were submitted for examination because they were considered backward by the schools. The group will therefore be referred to as 'Retarded' Group. This group contained 330 boys and 190 girls.

As with the Normal Group the Accomplishment Quotient was used to indicate the extent to which they were working to ability. It was found that 24 of these children were non-retarded in that the A.Q. was over 100.

The tables and figures following present the picture of the total Retarded Group N = 520 and refer to the 2nd testings re I.Qs. and A.Qs.

### Level of Intelligence.

The distribution of intelligence was made for boys and girls separately and plotted in terms of percentages at each 10 point interval of I.Q. and on the same axis for comparison. Fig. 10 presents the data.

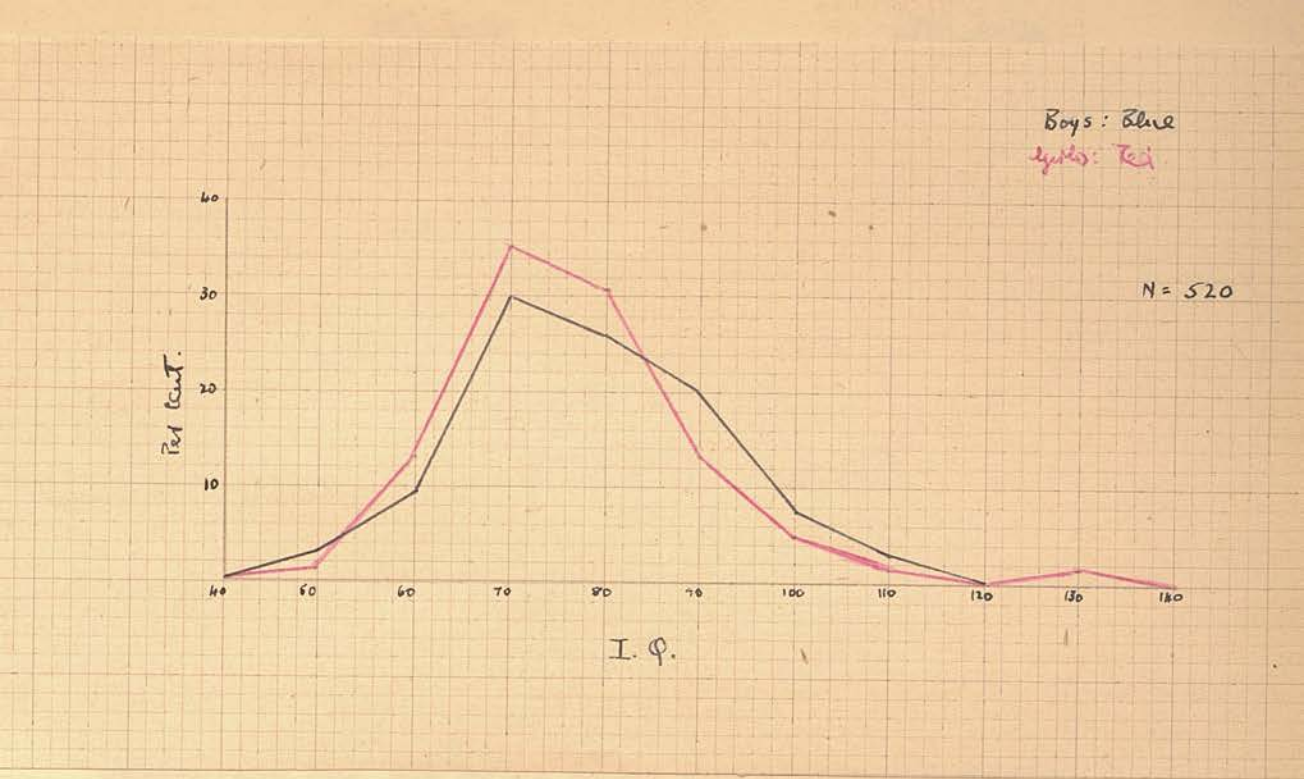



Fig. 10: Intelligence Quotients. Boys v Girls.

Weighting at the lowermost end of the scale can be observed for both boys and girls. This is not unexpected when the specific reason for referral is considered.

The Mean I.Q. for the total Retarded Group for 1st and 2nd I.Q. is -

| | 1st I.Q. | 2nd I.Q. |
|---|---|---|
| Mean | 83.04 ± 1.06 | 82.60 ± 1.14 |
| S.D. | 12.31 | 13.32 |

The Mean I.Q. for Boys and Girls alone on 1st and 2nd I.Q. is

| | 1st I.Q. | | 2nd I.Q. | |
|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. |
| Boys | 83.71 ± 1.32 | 12.28 | 83.29 ± 1.46 | 13.56 |
| Girls | 81.87 ± 1.75 | 12.32 | 81.39 ± 1.82 | 12.82 |

The difference between the means is not significant.

t - test results - Boys with Girls on

1st I.Q. = 1.65

2nd I.Q. = 1.56

The boys and girls are thus of similar intelligence level at a dull grading.

In Table 9 categories of intelligence for 2nd I.Q. are shown with the percentages found in the different categories for the total group and separately for boys and girls.

Table 9.

| I.Q. | Boys | Girls | All | Category |
|---|---|---|---|---|
| 130 + | | 1.05 | .38 | Very superior |
| 120-129 | .90 | .52 | .76 | Superior |
| 110-119 | 2.42 | 1.05 | 2.11 | High average |
| 100-109 | 7.87 | 4.73 | 6.92 | Normal or Average |
| 90- 99 | 19.69 | 13.15 | 18.07 | |
| 80- 89 | 26.36 | 30.52 | 26.92 | High grade dull to Low average |
| 70- 79 | 30.00 | 35.26 | 31.73 | Low grade dull |
| 60- 69 | 9.69 | 12.63 | 10.76 | Borderline defective |
| Below 60 | 3.02 | 1.05 | 2.30 | Mentally defective |
| N | 330 | 190 | 520 | |
| Mean 2nd | 83.29 ± 1.46 | 81.39 ± 1.82 | 82.6 ± 1.14 | |
| S.D. of I.Q. | 13.56 | 12.82 | 13.32 | |

Of particular interest is the range among this group specifically referred for backwardness - 55 I.Q. to 138 centred about a mean of 82.60 ± 1.14.

The considerable proportion of the group who are average in intelligence. Some 28.24% show I.Q. of 90 and above 90. 30.88% of the group are boys with at least normal intelligence while 20.50% are girls of this intelligence level. Where intelligence is below average, that is where I.Q. is below 90 - we find 79.46% of girls and 69.07% boys.

The difference in intelligence level between the boys and girls is not significant. Low capacity with this group may be exerting a major effect on sub-normal educational achievement, as the group show the intellectual level of the dull child with mean total I.Q. 82.60. The level of the boys is slightly higher than that of the girls but the difference is not significant. The group, therefore, is one of dull and backward children on intellectual finding and educational reference.

In this group of dull children a high percentage at defective level can be seen. With 70 I.Q. as the demarcation line we find 13.06% for the total group, with 12.71% boys and 13.68% girls. This higher percentage for girls is partly due to the high percentage of borderline cases among the girls. If levels below 60 only are considered then 2.30% for the total group can be seen with 3.02% boys and 1.05% girls. This is more akin to findings of previous investigations where the percentage of

defective boys exceeds girls. The high percentage must also be weighed in relation to the numbers in the groups as the proportion of boys to girls is almost 2 to 1.

Correlation Ratios.

The association between first and second intelligence test result was calculated.

The Correlation Coefficient for the Total Retarded Group r = .882 is significant at the .001 level.

This indicates high and close association with reliability in the testings.

The Relation of Attainment to Capacity.

The Relation of Attainment to Capacity was estimated for the total Retarded Group N = 520.

The Mean A.Q. for the Retarded Group for 1st and 2nd I.Q. is -

| | 1st A.Q. | 2nd A.Q. |
|---|---|---|
| Mean | 82.98 $\pm$ 1.08 | 82.58 $\pm$ 1.16 |
| S.D. | 12.52 | 13.48 |

A wide range of Accomplishment centres about a Mean of 82.58. These children therefore are working to 82% of their capacity.

The Mean A.Q. for Boys and Girls alone on 1st and 2nd A.Q. is -

| | 1st A.Q. | | 2nd A.Q. | |
|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. |
| Boys | 81.17 ± 1.33 | 12.32 | 80.23 ± 1.46 | 13.56 |
| Girls | 86.13 ± 1.74 | 12.26 | 86.66 ± 1.76 | 12.35 |

Considering the A.Qs. only, there are important differences between boys and girls which are sex determined.

Figs. 11 and 12 make these differences clear.

Fig. 11 gives the total A.Q. distribution for Boys and Girls separately, in terms of percentages at different levels of A.Q.

Fig. 12 shows A.Qs. below 100 for 2nd testing in terms of percentages below certain limits of A.Q. Fig. 12 therefore brings out the incidence of learning interference in these Retarded Boys and Girls.

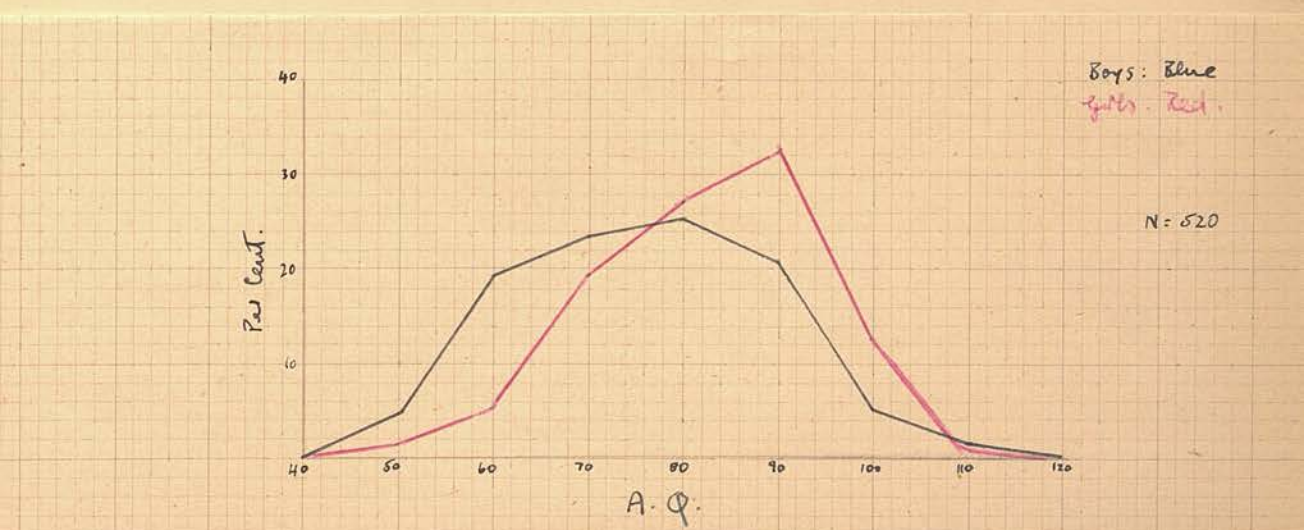



Fig. 11 A.Q.: Percentages at different levels of A.Q.

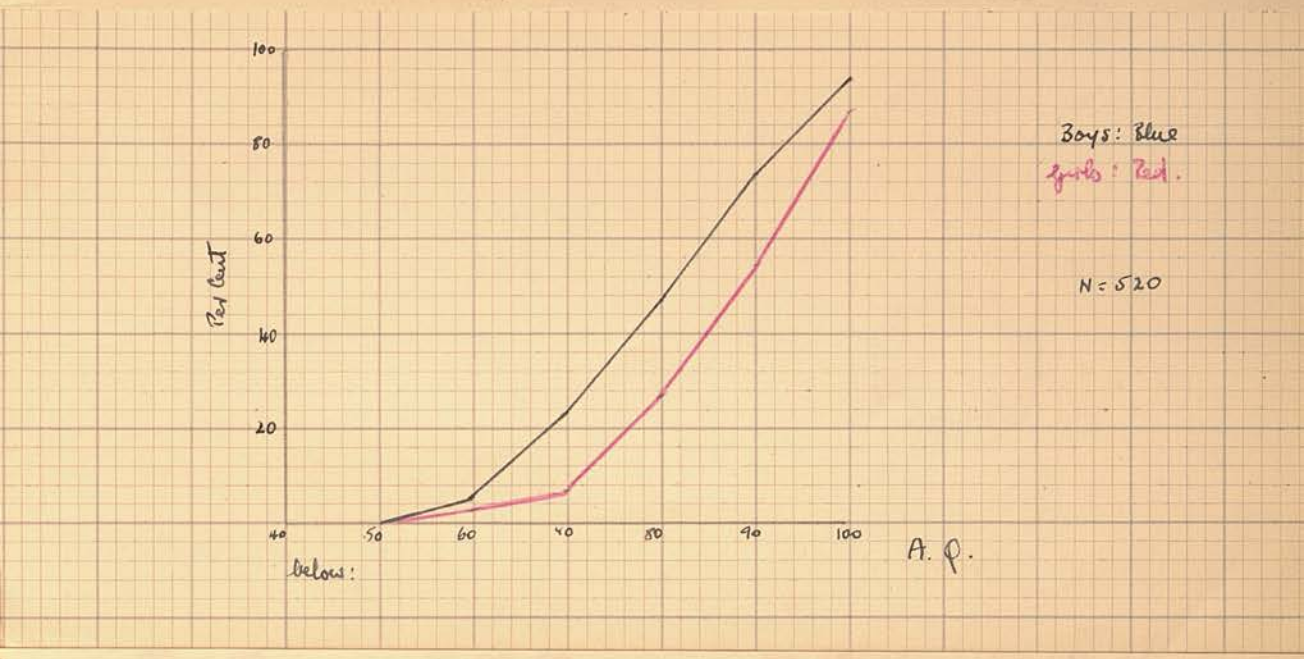



Fig. 12: Percentages below certain limits of A.Q.

Comparing the difference between the Means for Boys with Girls for the Retarded Group.

t - test results on Achievement are -

1st A.Q. 4.43

2nd A.Q. 5.38

Setting up the Null Hypothesis, on Achievement the results indicate that the probability is less than .001 that the difference observed is a chance one, and could be obtained on the Null Hypothesis; thus it can confidently be concluded that the difference is highly significant and that the boys differ from the girls and are poorer in performance. A sex difference is thus present with this Retarded Group.

Tables 10 and 11 present the data on which Figs. 11 and 12 are based.

Table 10.

Combined Reading and Spelling Accomplishment.

Percentages at Different Levels of A.Q. (2nd A.Q.)

| A.Q. | Boys | Girls | All |
|---|---|---|---|
| 140 - 149 | | | |
| 130 - 139 | | | |
| 120 - 129 | | | |
| 110 - 119 | 1.82 | 1.05 | 1.53 |
| 100 - 109 | 4.24 | 12.10 | 7.11 |
| 90 - 99 | 20.60 | 32.10 | 24.80 |
| 80 - 89 | 25.45 | 27.89 | 26.34 |
| 70 - 79 | 23.93 | 18.94 | 22.11 |
| 60 - 69 | 18.78 | 5.78 | 14.03 |
| 50 - 59 | 4.84 | 1.57 | 3.65 |
| 40 - 49 | .30 | .52 | .38 |
| N | 330 | 190 | 520 |
| Mean A.Q. | 80.23 ± 1.46 | 86.66 ± 1.76 | 82.58 ± 1.16 |
| S.D. of A.Q. | 13.56 | 12.35 | 13.48 |

Table 11.

Combined Reading and Spelling A.Q. percentage below certain limits of A.Q.

| | Reading and Spelling | | |
|---|---|---|---|
| Below A.Q. | Boys | Girls | All |
| 150 | | | |
| 140 | | | |
| 130 | | | |
| 120 | 100 | 100 | 100 |
| 110 | 98.18 | 98.95 | 98.46 |
| 100 | 93.93 | 86.84 | 91.34 |
| 90 | 73.33 | 54.73 | 66.53 |
| 80 | 47.87 | 26.84 | 40.19 |
| 70 | 23.93 | 7.89 | 18.07 |
| 60 | 5.15 | 2.11 | 4.03 |
| 50 | .33 | .53 | .38 |
| 40 | | | |
| N | 330 | 190 | 520 |
| Mean A.Q. | 80.23 ± 1.46 | 86.66 ± 1.76 | 82.58 ± 1.16 |
| S.D. of A.Q. | 13.56 | 12.35 | 13.48 |

At all levels of A.Q. below 100 we find higher percentage of boys than girls indicating greater incidence in boys than in girls of learning interference due to other factors than low capacity - or which may be due partly to factors of low capacity.

It is an interesting fact that this group were referred for Retardation. If one regards the Mean I.Q. of this group for boys and girls combined, it can be seen that the Mean I.Q. is 82.60 ± 1.14, S.D. = 13.32. The Mean A.Q. of the Group for Boys and Girls is 82.58 ± 1.16, S.D. 13.48. Thus the achievement of the group approximates to mental level and therefore with rigid adherence to I.Q. and A.Q. result only they should be classified as a dull group but non-retarded. In actual fact the specific variation of retardation within the group is great, particularly with the boys who are poorer than the girls. In 1948 a survey of reading attainments - Times Educational Supplement 14th August - made of over 4000 boys and girls between 6½ + and 11½ + years revealed that 24% boys and 17% girls were one year or more retarded in reading and 12% boys and 7.5% girls were two or more years retarded. This again reveals greater amount of retardation among boys as compared with girls and which is also inherent in this group of Retarded children. Burt (11) found in his London and Birmingham Surveys that 82% of the backward pupils fell in the groups with I.Qs. 90 and under, and 55.2% I.Q. 85 and under (excluding mentally defective).

An investigation of backward children in 1932 by Sleight (93) showed that taking I.Q. 85 as the upper limit for dullness, 84.5% of 739 backward children tested were below that figure: taking I.Q. 90 as the limit, then

72.3% of Sleight's children fell in the low group. In 1947 in Glasgow (37) an examination of 300 backward junior secondary pupils revealed that 77.5% were of 85 and lower I.Q.

In this Retarded Group the mean I.Q. is below 85 and the percentage of children below 90 A.Q. is 66.53%. This is therefore a lower figure than that obtained by Sleight although a different number in each total group of children were involved. If 100 A.Q. is accepted as average and below that all degrees of subnormal achievement are revealed then 91.34% of the group are found including mentally defective children. The group are therefore correctly designated 'backward' when compared with average performance.

Correlation Ratio.

The correlation ratio relating language accomplishment to intelligence was calculated for the total Retarded Group and also for Boys and Girls separately.

The Correlation for the Total children is r = -.060

for Boys alone r = -.050

for Girls alone r = -.038

These correlations are not significant and do not bear out the inference that as Intelligence increases, so Achievement diminishes. One can conclude therefore that the Retarded Group are working consistently well or working to mental level more nearly than are the Normal Group.

A clear picture can be obtained by plotting 2nd A.Q. with 2nd I.Q. and then subdividing the grid to separate children of below average intelligence, i.e. I.Q. less than 90 - from those who are average or above average intelligence, i.e. I.Q. 90 and above 90. Likewise a horizontal line of division will give two accomplishment groups - those children of A.Q. 100 and above 100 and those of A.Q. less than 100. This is illustrated by the following diagram showing the percentage in each category.

| | Below 90 I.Q. | Above |
|---|---|---|
| above 100 A.Q. | A. 5.96% | C. 2.69% |
| below | B. 65.76% | D. 25.5% |

The following groups can then be seen:

A + B 72% where Intelligence is 'below average' and associated with a total range of A.Q.

A 5.96% Retardation explicable in terms of low capacity alone (i.e. I.Q. less 90, A.Q. 100 or above).

B 65.76% Retardation due to a combination of low capacity and learning interference (I.Q. less 90, A.Q. below 100).

C + D 28.19% Intelligence average or above average and associated with a total range of A.Q.

C 2.69% No educational problem (I.Q. is above

90 and A.Q. is above 100).

D 25.5% Retardation due to learning interference outwith capacity. (I.Q. is 90 or above and A.Q. is less 100).

B + D 91.26% where learning interference is evident with intelligence equated out.

Table 12 presents the percentages of the Retarded Group in these categories.

Table 12.

Categories of Accomplishment and Intelligence.

Percentages.

| Category | Boys | Girls | All |
|---|---|---|---|
| A + B | 69.08 | 79.46 | 71.72 |
| A | 5.15 | 10.52 | 5.96 |
| B | 63.93 | 68.94 | 65.76 |
| C + D | 30.90 | 20.52 | 28.19 |
| C | .90 | 2.63 | 2.69 |
| D | 30 | 17.89 | 25.5 |
| B + D | 93.93 | 86.83 | 91.26 |

It is interesting that in category 'C' 'no educational problem', the percentage for girls exceeds that of the boys.

A marked difference between Girls and Boys is again apparent in Category D, where retardation may be attributed to learning interference outwith capacity.

In these incidences the essentials of the Achievement to Intelligence relationship can be seen.

Interesting points are the very small percentage of the group in C - 2.69% who show no educational problem. As these children were referred for backwardness this is what might be expected.

The very great number in B + D - 91.26% who show the impress of learning interference associated with a total range of I.Q.

The high percentage D - 25.5% where retardation is extraneous to capacity. The high percentage in B - 65.76% associated with low intelligence and factors of learning interference combined.

Summarising the Findings for the total Retarded Group.

The intelligence level of the group approximates to the dull category and is below average, with no significant difference found between the girls and boys.

In Achievement this group are working below average but in keeping with their mental level. The boys however show a significantly poorer level than the girls.

A very high incidence of language disability is present - only some 3% presenting no problem.

Factors associated with low capacity might explain the major retardation with this group. Although a high

percentage of extraneous learning interference can be seen - 91.26% when intelligence is equated out.

There is no significant relationship in the correlation ratios of the group relating language accomplishment to intelligence although these are negative.

The correlation ratio of the first and second test is sufficiently significant to weight the testings as reliable.

## References.


11. Burt C. The Backward Child. New York. MacMillan, 1937.

93. 1932 - Sleight. The Diagnosis and Treatment of the Backward Child (Ph.D. Thesis 1932 - University of London Library.)

37. 1947 - Backward Pupils in Secondary Schools: Report of Headmasters' Association and Headmistresses' Association. City of Glasgow 1947.

1948 - Attainment in Reading. Times Educational Supplement. Aug. 14.

## Chapter 3 (c)

## Analysis of Twin Group.

The Twin group ultimately retained for testing and analysis, numbered 344 children, 166 boys and 178 girls. As with the other groups a general analysis of their intellectual and educational achievement in tests of Reading and Spelling is presented before consideration of laterality factors.

In the Twin Group, 62 children were found whose A.Qs. were over 100 and therefore were non-retarded by the criterion of A.Q. below 100.

### Intelligence Level.

The following figures and tables refer to the 2nd Intelligence Quotient and 2nd Accomplishment Quotient and the group is studied as a whole, i.e. N = 344.

The distribution of intelligence for girls separately and for boys separately was drawn in Fig. 13 in terms of percentage levels and on the same axis for comparison.

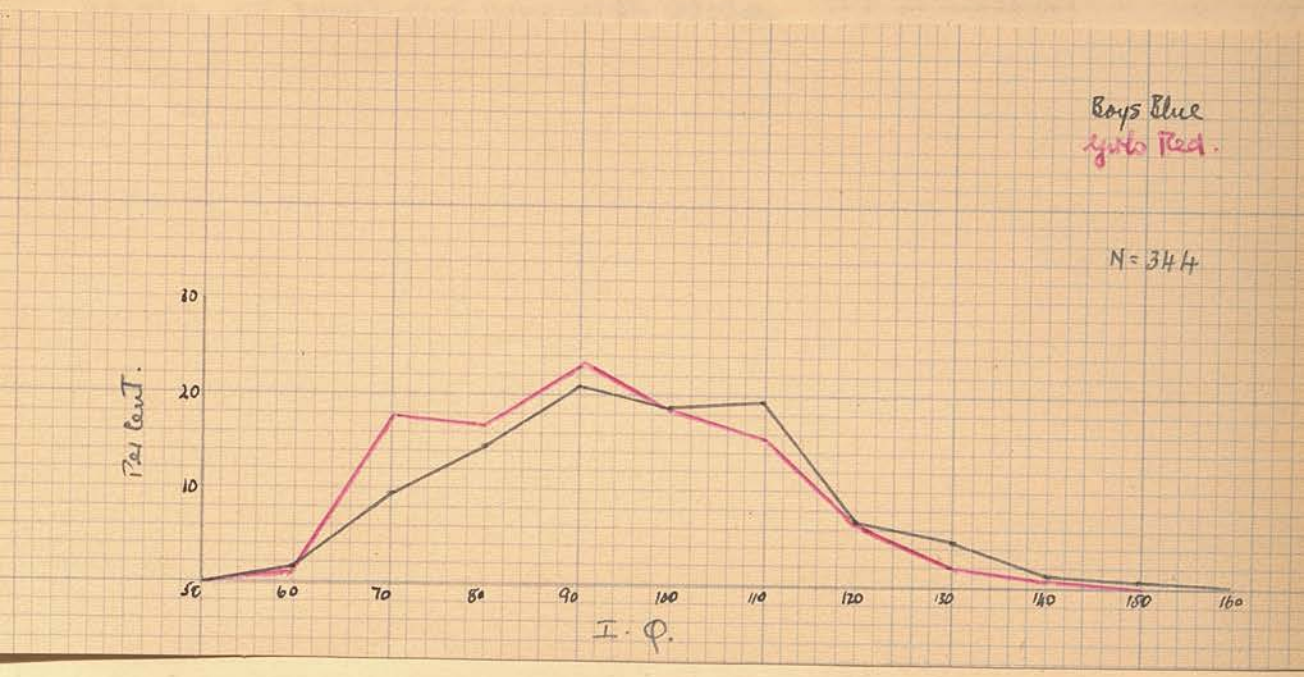



Fig. 13. Intelligence Quotients: Boys v Girls.

The mean I.Q. of the total Twin Group for 1st and 2nd I.Q. is -

| | 1st I.Q. | 2nd I.Q. |
|---|---|---|
| Mean | 97.20 ± 1.93 | 98.34 ± 1.87 |
| S.D. | 18.31 | 17.66 |

The mean I.Q. for Boy Twins and Girl Twins alone on 1st and 2nd I.Q. is -

| | 1st I.Q. | | 2nd I.Q. | |
|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. |
| Boys | 99.26± 2.90 | 19.09 | 100.46 ± 2.83 | 18.59 |
| Girls | 95.29± 2.55 | 17.38 | 96.35 ± 2.43 | 16.52 |

The difference between the Means is significant at the .05 level for Boys with Girls.

t - test results for 1st I.Q. = 2.02

t - test results for 2nd I.Q. = 2.17

thus indicating that in our group of twins the intelligence of the boys is significantly higher than the girls.

In Table 13 categories of intelligence for 2nd I.Q. are shown with the percentages found in the different categories for the total Twin Group and separately for boy and girl twins.

Table 13.

| I.Q. | Boy Twins | Girl Twins | All Twins | Category |
|---|---|---|---|---|
| 130 + | 6.02 | 2.24 | 4.06 | Very superior |
| 120-129 | 7.23 | 6.17 | 6.68 | Superior |
| 110-119 | 19.88 | 15.17 | 17.44 | High average |
| 100-109 | 18.67 | 17.97 | 18.31 | Normal or average |
| 90- 99 | 20.47 | 22.47 | 21.51 | |
| 80- 89 | 14.46 | 16.85 | 15.69 | High grade dull to low average |
| 70- 79 | 9.64 | 17.42 | 13.95 | Low grade dull |
| 60-69 | 1.81 | .56 | 1.16 | Borderline defective |
| Below 60 | 1.81 | .56 | 1.16 | Mentally defective |
| N | 166 | 178 | 344 | |
| Mean 2nd I.Q. | 100.46 ± 2.83 | 96.35 ± 2.43 | 98.34 ± 1.87 | |
| S.D. of I.Q. | 18.59 | 16.52 | 17.66 | |

Of particular interest is the wide range of capacity among the total twins 57 to 155 I.Q. centred about a mean of 98.34 ± 1.41: the considerable proportion of the group who are of average or above average intelligence. Some 68% show I.Q. of 90 and above 90; 72.27% of the boys group are boys with at least normal intelligence, while 64.02% are girls. Where intelligence is below average, i.e. where I.Q. is below 90, we find 35.39% girls and 27.72% boys.

The difference between the boy twins and girl twins indicates a significant difference in intelligence in favour of the boy twins.

The mean intelligence quotient for the total Twin Group on first testing is 97.20 and 98.34 I.Q. on 2nd testing. This is below the mean I.Q. for the Normal Group which in this study is 102.56. The Twins as a group are therefore lower in intelligence than the non-twins. This finding is in agreement with the previous investigations on twins. Merriman (64) found a median I.Q. of 97 for twins, using Stanford Binet, Army Beta and National Intelligence Tests on over one hundred pairs. Lauterbach 1925 (54) with 208 pairs of twins tested by National Intelligence Tests and the Terman Group Test of Mental Ability, found no evidence that twins were intellectually handicapped. The median I.Q. Lauterbach found to be 95: Holzinger 1929 (46) found that twins had the same average intelligence as unselected children.

Wingfield and Sandiford (113) in a study of 102 pairs of twins state that twins as a group are very slightly below average of the population in general intelligence, but show approximately the same degree of variability as unselected children. 97.2 is given as their mean I.Q. finding. More recently from the Scottish 1947 Mental Survey data, Mehrotra and Maxwell (63) studied the group intelligence test scores of 974 twins. They found that the intelligence of twins was markedly lower than that of non-twins. They also noted that the girl twins had a higher mean test score than the twin boys. In the present group of 172 pairs of twins the mean I.Q. of the boys was significantly higher than of the girls, but the numbers in the present group are small for valid generalisation. The previous estimations of intelligence have been made on Group Tests. The present finding is based on an individual test and retest. An interesting point is the statement by Mehrotra and Maxwell that the average intelligence test score of twins is found to be lower, to the extent of about five points in I.Q. than that of non-twins among 11 year old Scottish children.

In the present study the difference between 2nd I.Q. finding of twins and non-twins is 4.22 in favour of non-twins which is in fair agreement although on a smaller sample.

An interesting feature of the category classification

is that 4.06% of all the twins enter the 'very superior' grading with 6.02% boys and 2.24% girls. This total percentage is high but is still below the 5% found for all children in the Normal group in the 'very superior' category, thus in this present study more non-twins than twins show a higher level of intelligence.

At the lower end of the scale, the percentage of twins entering the defective category is 2.32% for all twins if 70 I.Q. is chosen as the line of demarcation, 3.62% boys and 1.12% girls. Below 60 I.Q. the percentage for all twins is 1.16% with 1.81% boys and .56% girls. The twin group bears out the suggestion that a higher percentage of boys are found in the defective category, than girls.

The percentage of twins entering the defective category is seen to be lower than that of non-twins, as 3.33% of all children in the Normal Group fell below 70 I.Q. while 2.32% of twins fell below 70 I.Q. Below 60 I.Q. the percentage for non-twins or the Normal Group was 1.11% while for twins the percentage found was 1.16% showing a very slight rise for twins. It is interesting that in the Normal Group 3.75% girls fell below 70 I.Q. while with Twins 1.12% of girls entered this category. With boys in the Normal Group 3.00% fell below 70 I.Q. while 3.62% of twin boys entered this category. There are therefore smaller percentages of twin girls below

70 I.Q. compared with the Normal while a slightly higher percentage of twin boys enter the 70 - category. The numbers in the two groups however vary considerably as Normal Group N = 180 while Twin group N = 344.

Correlation Ratios.

The association between 1st and 2nd intelligence test result was computed. The ratio or r = .844 is significant at the .001 level. Thus close and reliable relationship has been found in the testings.

The Relation of Attainment to Capacity.

The relation of attainment to capacity was calculated for the total Twin Group.

The Mean A.Q. for the total Twin Group for 1st and 2nd A.Q. is -

| | 1st A.Q. | 2nd A.Q. |
|---|---|---|
| Mean | 90.98 $\pm$ 1.41 | 90.78 $\pm$ 1.39 |
| S.D. | 13.30 | 13.14 |

The Accomplishment Quotients indicate the extent to which the children are working up to capacity in the educational tests combined.

A wide range of accomplishment centres about a Mean of 90.78. On the average then, the Twin Group is working at approximately 91% of its capacity.

The Mean A.Q. for Twin boys and girls alone on 1st and 2nd A.Q. is -

| | 1st A.Q. | | 2nd A.Q. | |
|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. |
| Boys | 87.81 ± 2.00 | 13.14 | 87.87 ± 2.07 | 13.64 |
| Girls | 93.94 ± 1.88 | 12.79 | 93.49 ± 1.77 | 12.08 |

Considering the A.Qs. only there are important differences which are basically sex determined.

Figs. 14 and 15 make these differences clear.

Fig. 14 gives percentages of the Twin Group at different levels of A.Q. for Boy and Girl Twins separately, while Fig. 15 shows A.Qs. below 100 for the 2nd Testing in terms of percentages below certain limits of A.Q. This therefore, brings out the incidence of learning interference in these twin boys and girls.

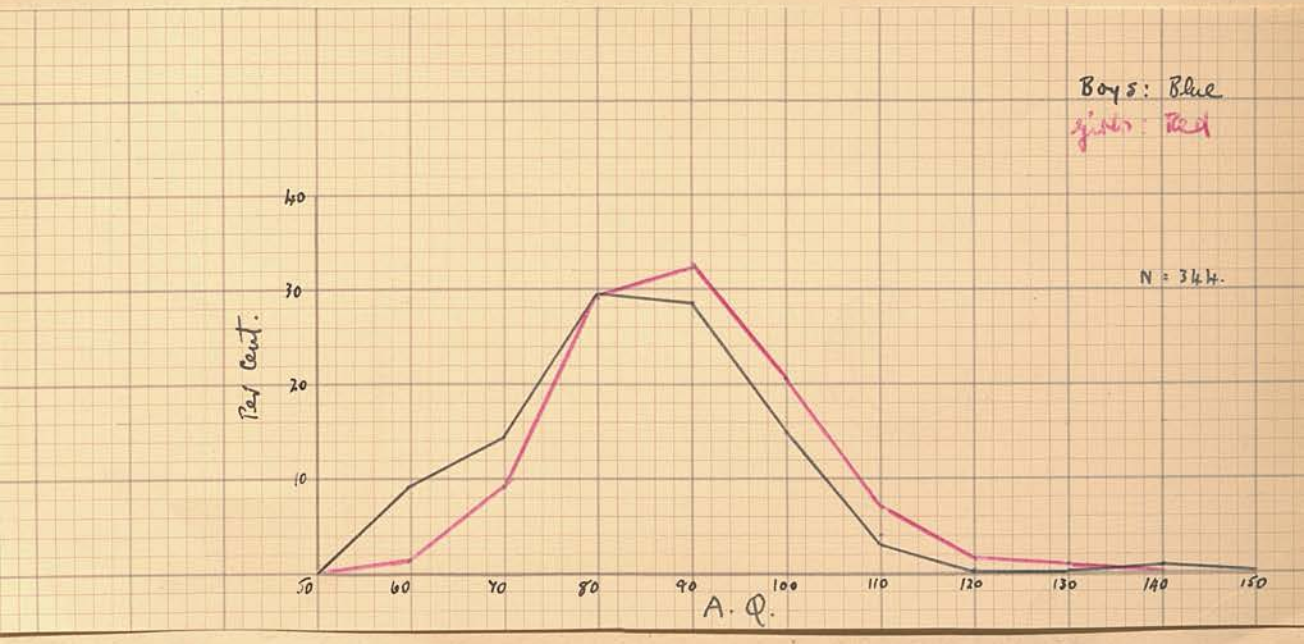



Fig. 14.

Percentages at different levels of A.Q. - Twin Group.

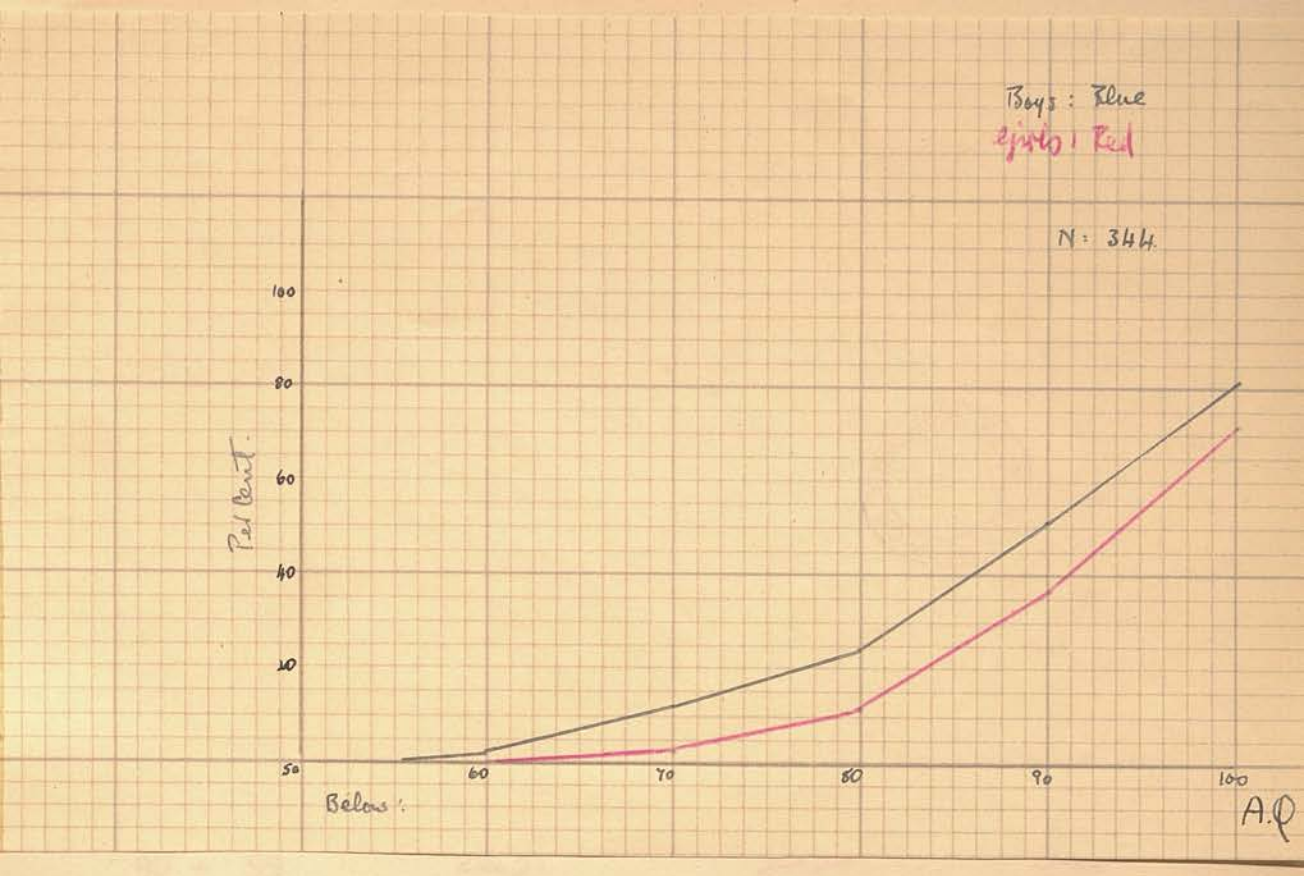



Fig. 15.

Percentages of Twin boys and girls below certain limits of A.Q.

Comparing the means and testing for Sex Difference for the Twin Group the t - test results on Achievement are -

1st A.Q. 4.39

2nd A.Q. 4.05

Both results show a significant difference at the .001 level or the probability of the difference arising by chance is less than 1 in 1000. Hence it would appear that a significant sex difference exists with reference

to educational achievement between boy twins and girl twins, the boys being definitely poorer.

Tables 14 and 15 present the data on which Figs. 14 and 15 are based.

Table 14.

Combined Reading and Spelling Accomplishment Quotient Percentages at Different Levels of A.Q.

| A.Q. | Boys | Girls | All |
|---|---|---|---|
| 140 - 149 | .60 | | .29 |
| 130 - 139 | 0 | .56 | .29 |
| 120 - 129 | 0 | 1.68 | .87 |
| 110 - 119 | 3.01 | 6.17 | 4.65 |
| 100 - 109 | 14.46 | 20.22 | 17.44 |
| 90 - 99 | 28.31 | 32.58 | 30.52 |
| 80 - 89 | 28.92 | 28.09 | 28.48 |
| 70 - 79 | 14.46 | 9.55 | 11.91 |
| 60 - 69 | 9.04 | 1.12 | 4.94 |
| 50 - 59 | 1.20 | | .58 |
| 40 - 49 | | | |
| N | 166 | 178 | 344 |
| Mean A.Q. | 87.87 $\pm$ 2.07 | 93.49 $\pm$ 1.77 | 90.78 $\pm$ 1.39 |
| S.D. of A.Q. | 13.64 | 12.08 | 13.14 |

Table 15.

Combined Reading and Spelling Accomplishment Quotient

Percentages below certain limits of A.Q.

| Below A.Q. | Boys | Girls | All |
|---|---|---|---|
| 150 | 100. | | 100. |
| 140 | 99.39 | 100. | 99.70 |
| 130 | 99.39 | 99.43 | 99.41 |
| 120 | 99.39 | 97.75 | 98.54 |
| 110 | 96.38 | 91.57 | 93.89 |
| 100 | 81.92 | 71.34 | 76.45 |
| 90 | 53.61 | 38.76 | 45.93 |
| 80 | 24.69 | 10.67 | 17.44 |
| 70 | 10.24 | 1.12 | 5.52 |
| 60 | 1.20 | | .58 |
| 50 | | | |
| N | 166 | 178 | 344 |
| Mean A.Q. | 87.87 ± 2.07 | 93.49 ± 1.77 | 90.78 ± 1.39 |
| S.D. of A.Q. | 13.64 | 12.08 | 13.14 |

At all levels of A.Q. below 100, we find consistently higher percentages of boys than girls, indicating higher incidence in boys than in girls of learning interference due to other factors than low capacity.

Correlation Ratios.

In relating language accomplishment to intelligence

the correlation of the total Twin Group in Achievement and Intelligence was calculated for boys and girls combined and for twin boys and girls separately.

The Correlation coefficient for twin boys + girls on 2nd I.Q. with 2nd A.Q. =

$$r = -.170$$

This is significant at the .05 level and indicates that with a negative association, the A.Q. decreases as the I.Q. increases. The suggestion is that the more intelligent twins are not working so hard as those of lower intelligence or that cleverer twins are showing wider discrepancy between potentiality and achievement.

The r for Boys alone = -.049

and The r for Girls alone = -.269

The association is not significant with the boys but is highly significant with the girls being significant at the .001 level. The more intelligent twin girls are thus not working so hard as those girl twins of lower I.Q. or the clever girl twins are showing poorer scores in the educational tests.

A clear picture can be seen of the relation of language accomplishment to intelligence by plotting A.Q. with I.Q. and then subdividing the grid to separate children of 'below average' intelligence, i.e. I.Q. less than 90 - from those who are average and above average intelligence, i.e. I.Q. 90 and above 90. Likewise a horizontal line of division will give two

accomplishment groups - those children of A.Q. 100 and above 100 and those of A.Q. less than 100. This is illustrated by the following diagram with the percentages of each group in the different categories.

| | below 90 I.Q. | above |
|---|---|---|
| above 100 A.Q. | A. 11.04% | C. 12.5% |
| below | B. 20.96% | D. 55.5% |

The following groups can then be seen:

A + B 32.00% where intelligence is 'below average' associated with a total range of A.Q.

A 11.04% where retardation is explicable in terms of low capacity alone (i.e. I.Q. less 90, A.Q. 100 or above)

B 20.96% where retardation is due to a combination of low capacity and learning interference (I.Q. less 90 and A.Q. below 100).

C + D 68% where intelligence is average or above average and associated with a total range of A.Q.

C 12.5% no educational problem (I.Q. is above 90 and A.Q. is above 100).

D 55.5% where retardation is entirely due to learning interference outwith capacity. (I.Q. is 90 or above and A.Q. is less than 100).

B + D 76.46% where retardation apart from capacity can be observed when intelligence is equated out.

Table 16 presents the percentages of the Twin Group in these categories for Boy and Girl Twins.

Table 16.

Categories of Accomplishment and Intelligence.

| Category | Boys | Girls | All |
|---|---|---|---|
| A + B | 27.70 | 35.95 | 32.00 |
| A | 6.02 | 15.73 | 11.04 |
| B | 21.68 | 20.22 | 20.96 |
| C + D | 72.28 | 64.04 | 68.0 |
| C | 12.04 | 12.92 | 12.5 |
| D | 60.24 | 51.12 | 55.5 |
| B + D | 81.92 | 71.34 | 76.46 |

In category 'C' both boy and girl twins show similar percentages where no educational problem is apparent. The boy twins show a greater percentage in category 'D' where retardation may be attributed to learning interference outwith capacity. This trend has been apparent throughout the subgroups studied.

In these incidences the essentials of the achievement to intelligence relationships can be seen.

Interesting points are the small percentage in C - 12.5% of the total Twin Group who show no educational problem. Also the small proportion of 11.04% in A where learning interference can be explained in terms of low capacity. The very high percentage in D where children of average or above average are working below capacity -

55.5% where learning interference would appear to be due to factors of learning interference outwith capacity.

The considerable proportion of 76.46% of the twins who show the total impress of learning interference when intelligence is equated out.

In the Boys group 81.92% of the boys and 71.34% of girls are working below capacity in the educational tests.

Summarising the findings for the total Twin Group.

The intelligence level of the total Twin Group approximates to the average but is in keeping with other investigations of the intelligence level of twins as compared with non-twins in that the twin level is slightly lower.

The sex difference in twins is significant with a slightly higher level of intelligence among the boys in the group.

In achievement however the group as a whole are working below capacity. The boys are significantly poorer than the girls in language accomplishment.

A high incidence of language disability is present, there being only some 12% who show no educational problem, in that intelligence is average or above average and achievement is above 100.

Factors extraneous to capacity must therefore be sought to explain the major part of retardation, particularly with the boys. A considerable impress of

learning interference is present, some 76% of the children being affected, and associated with a total range of I.Q. Of these children a significantly greater proportion are boys, the majority of whom are average and above average intelligence.

The relationship of Achievement to intelligence is negative and suggests that in the total group of Twins, those of higher I.Q. are achieving least well. This relationship is highly significant with the girl twins, in negative association, such that it can be inferred that the more intelligent girl twins do not appear to be working so hard as those of a lower level.

## References.


64. C. Merriman. The Intellectual Resemblance of Twins. Psychological Monographs Vol. XXXIII, No. 5, 1924.

54. C.E. Lauterbach. Studies in Twin Resemblance. Genetics Vol. X 1925, 525 - 68.

46. K.J. Holzinger. The Relative Effects of Nature and Nurture Influences on Twin Differences - Journal of Educational Psychology. Vol. XX 1929, 241 - 8.

113. A.H. Wingfield and P. Sandiford. Twins and Orphans. Journal of Educational Psychology. Vol. XIX 1928, 410 - 23.

63. S.N. Mehrotra and J. Maxwell. The Intelligence of Twins. A Comparative Study of Eleven year old Twins. Population Studies. Vol. III No. 3 1949.

## CONCLUSION

### Background Situation.

The foregoing analysis of the respective groups has revealed that the Normal and Twin groups approximate to the average in intellectual level while the Retarded group enters the dull category. There is no apparent sex difference in intelligence with the exception of the Twin group, where the boy twins show a significantly higher level of intelligence than the girl twins. When the subgroups are combined this difference becomes merged in the Total group which reveals no significant difference.

The retardation situation presents a different picture. The Normal and Twin groups, of average intellectual level, were found to be achieving at a lower level than potential. The Retarded group who were observed to be one of intellectually dull level were found to be achieving at mental level, although the achievement of the group as a whole is well below that of average performance.

Further in each group, a significant difference in achievement between boys and girls was found: the boys working at a lower level than the girls. Educational attainment has been measured in the elementary skills of mechanical reading and spelling only, yet there is sufficient evidence to make the sex difference a real one. The question therefore arises, why should boys be poorer in

attainment?

A further interesting point lies in the tendency for the clever children to be showing greatest discrepancy between potential and performance. This was more marked with the girls than with the boys.

Many factors may be operating, comprising the recognised causative factors of backwardness - environmental, temperamental, congenital, social, physical. The one of interest for our enquiry lies in the operation of laterality factors. Thus do the laterality characteristics of each group vary in any marked way? Further, do boys differ significantly from the girls in laterality, in such a manner that these influences may be affecting their scholastic achievement adversely?

These and allied questions can only be answered after the influence of laterality has been studied in the groups, and its association with intelligence and achievement, if any, measured both with boys and girls.

This investigation will form the main topic of the following section.

## SECTION II

### Chapter 4.

### Laterality Trends - Preliminary Review.

In surveying the original 1044 children as regards Laterality the writing hand was noted on first testing and taken as evidence of handedness, right or left. A short eye test was given - Cylinder eye test - this consisted of a small cardboard cylinder which the subject picked up and placed to one eye. He was instructed to close one eye and look with the other through this cardboard tube. Three trials were given. The dominant eye was considered to be right or left according as a score of 3/3 was obtained or 2 out of 3 on three trials given. The numbers and percentages for the results of these two observations on Hand and Eye were calculated as a preliminary survey. The incidence of 'handedness' in the two categories was first found.

Table 17 presents the numbers and percentages of righthanded and lefthanded children found for the Total Group of 1044 children, irrespective of eyedness.

Table 17.

| | Boys | | Girls | | Total | |
|---|---|---|---|---|---|---|
| Hand | Nos. | % | Nos. | % | Nos. | % |
| Right | 537 | 51.43 | 404 | 38.69 | 941 | 90.13 |
| Left | 58 | 5.55 | 45 | 4.31 | 103 | 9.86 |
| | 595 | | 449 | | 1044 | |

A higher percentage of lefthanded boys than girls appears in this first superficial survey of over 1000 children. The percentage of approximately 10% for lefthandedness is in agreement with general investigations.

Hand and eye were then combined to form classifications of pure dextrals, i.e. righthand, right eye: pure sinistrals, i.e. lefthand, left eye: and cases of mixed hand and eye or crosslaterals, i.e. righthand left eye and lefthand right eye. The tables presenting these numbers and percentages can be found in Appendix B, Tables 3 - 6, firstly for the Total Group of 1044 children and then for the respective subgroups of Normal, Retarded and Twin Group.

While the hand and eyedness of the children are superficially noted and the numbers in the groups vary, characteristics of each group are interesting.

Total Group.

The percentages reflect in the main the findings of previous investigators although the percentages of pure sinistrals and crosslaterals, lefthanded righteyed are somewhat lower. This may possibly be due to the fact that innate lefthanders are masked by the influences of training or 'acquired' handedness. Children who were born with a strong predisposition to lefthandedness may now through the effects of parent or teacher persuasion, be writing with the righthand. This influence may be operating in the Crosslateral categories as the

percentage of righthanded lefteyed children is much greater than the percentage of lefthanded righteyed, 32.95% in the former category to 5.55% in the latter category, for all children. When the crosslateral categories are combined, a higher percentage of boys than girls appears. These categories and this preliminary survey, do not therefore bring out a group of children, who may be termed 'shifted sinistrals'. This group, if it exists and if it is operating among the righthanders, may be exerting a significant influence on the performance of these righthanders, if we accept the hypothesis that to change the hand of a child is detrimental to performance at maximum potentiality. Thus in studying handedness and eyedness in any group it is essential that adequate tests be used which will reveal so far as is possible the tendencies to native or acquired handedness. Eyedness is more difficult to determine as the hypothesis that eyedness is 'acquired' seems dubious. At the same time a reliable index of eyedness may be more easily found if one considers eyedness as being either dominantly right or left.

Subgroups.

In considering the subgroups Retarded, Normal and Twin the general trend as for the Total group is borne out that the largest percentage in each category is in the pure dextral category. The smallest percentage is in the pure sinistral group with a higher percentage in

the mixed hand and eye groups of righthanded lefteyed when compared with lefthanded righteyed.

In the crosslateral righthanded lefteyed groups the Retarded and Twin groups show higher percentages of boys than girls but the Normal group is the exception with a higher percentage among the girls. In the second mixed hand-eye group of lefthand right eye there is agreement in the groups with the boys showing a higher percentage than the girls except for the Twins which are approximately equal.

If the crosslateral categories are combined for each group, a higher percentage of boys than girls appears except in the Normal group where the results show a higher percentage of girls, e.g.

Retarded Group Mixed hand eye combined
i.e. RH.LE + LH.RE Boys 42.11% Girls 35.78%

Twin Group Mixed hand eye combined Boys 40.35% Girls 35.39%

Normal Group Mixed hand eye combined Boys 33.32% Girls 38.38%

There is thus no consistent trend among the groups in hand and eye combinations with the exception of the Pure Sinistrals where in each group appears a tendency for girls to show a higher percentage than boys although this is not so strongly evident with the Retarded group. With the crosslateral categories combined, the percentage difference in the Twin and Retarded group is greater for the boys than in the Normal group where the numbers being smaller may be influencing the result.

This factor of smaller percentages for boys in the

Pure Sinistral category is interesting in the suggestion it holds of the social necessity for a boy to use or be 'forced' to use his right hand although innately left handed. Such urgency may not be associated with girls. The mixed groups of hand and eye combined show a higher percentage for boys, largely due to the high percentages in the righthanded lefteyed categories. Social pressure may be evident here also in that complete changeover has not been successfully effected in the cases of righthand left eyedness. The result therefore may be associated with the lower attainment of boys compared to girls but a more detailed investigation as in the following chapters is necessary before such a hypothesis can be substantiated or otherwise.

Eyedness in Preliminary Survey of Laterality.

To test eyedness the children were given a short cardboard cylinder through which they looked. This was picked up with the right hand, with the left hand and then with both hands. A point in the room was fixated and the eye used for sighting, noted in each case. Children were regarded as being right or left eyed as they scored 3/3 with one or other eye and a score of two trials out of three was allocated to right or left accordingly.

In the group of 1044 children, 655 boys and girls or 62.73% were found to be right eyed while 389 children, boys + girls or 37.26% were found to be lefteyed. The suggestion is therefore that right eyedness is more frequent

and normal in the population. These percentages agree in the main with previous investigators. Miles (65) in an investigation of 203 adults found 66% right sighting with 31.5% left sighting. Similarly with 172 pre-school children this same investigator found 67% righteyed and 30% lefteyed. Hildreth (41) in an investigation of 191 private school children, found 56.2% righteyed and 36.6% lefteyed. Jastak (47) in examining 820 cases, although he did not state the type, reported 55.8% righteyed and 36.4% lefteyed. Schonell (88) in an examination of 75 children, found 63% righteyed and 29% lefteyed.

All these investigators agree in finding the highest percentage among righteyed children at or about the 60% figure. The differences in the percentages relate to the differing numbers of cases in each sample. The present percentages are therefore in close agreement with them.

In surveying the eyedness of the subgroups, Retarded Normal and Twin, the pattern of the Total Group is followed the percentage of righteyed being greater than for lefteyed.

Table 18 presents the percentages of eyedness found in the respective groups.

Table 18.

Eyedness of Retarded Group. N = 520

316 Boys + Girls or 60.76% were righteyed.

204 Boys + Girls or 39.23% were lefteyed.

Normal Group. N = 180

121 Boys + Girls or 67.2% were righteyed.

59 Boys + Girls or 32.7% were lefteyed.

Twin Group. N = 344

218 Boys + Girls or 63.3% were righteyed.

126 Boys + Girls or 36.6% were lefteyed.

Observation shows that the highest percentage of righteyed children falls in the Normal Group with the lowest percentage of lefteyed children in the Normal Group also.

A higher percentage of righteyed children fall in the Twin Group than in the Retarded Group, while the highest percentage of lefteyed children falls in the Retarded Group. The high percentage of lefteyed children in this group is interesting in that the Retarded Group as a whole is composed of dull children.

A more detailed investigation of eyedness later will reveal if these superficial trends are established as a general pattern or whether true eyedness can be gauged only by a variety of tests. The concept of 'acquired' eyedness is more difficult to establish than that of 'acquired' handedness.

Summarising the findings of the Preliminary Hand-Eye Survey.

The main trend in the Total Group is for the highest percentage to be Pure Dextral with the lowest percentage Pure Sinistral.

In the Crosslateral groups combined, i.e. RHLE + LHRE a higher percentage of boys than girls is apparent. This trend of Crosslaterals is also apparent with Twin and Retarded Groups: the Normal Group being an exception.

The percentages of Pure Sinistrals are slightly lower than found in previous investigations.

In the Subgroups of Normals, Twins and Retarded, the highest percentages fall in the Pure Dextral categories with the lowest percentages in the Pure Sinistral.

In every group a higher percentage of RHLE category can be seen compared with LHRE.

No consistent trend is found in the groups except for the Pure Sinistrals where in each group, girls show a slightly higher percentage than boys.

In eyedness highest percentages are found in the righteyed group with the lowest percentages in the lefteyed groups. In the subgroups the same trend is noticeable. The highest percentage of righteyed children is seen in the Normal Group with the lowest percentage of lefteyed children also in the Normal Group. The highest percentage of lefteyed children is seen in the Retarded Group.

## References.


65. Miles W.R. - Ocular Dominance demonstrated by unconscious sighting. J. Experimental Psychology, 1929 - 12, 113-126.

41. Hildreth G. - A School Survey of Eye, Hand Dominance. J. of Applied Psychology, 1945,-29, 83-88.

47. Jastak J. - The Ambigraph Laterality Test. J. of Applied Psychology, 1939 - 23, 473-487.

88. Schonell F.J. - The Relation of Reading Disability to Handedness and certain Ocular Factors. II British Journal of Educational Psychology. 1940 - 10,3 and 11,1,1941.

## Chapter 5.

## Analysis of Laterality Characteristics of the Groups - Incidence.

The Total Group of 1044 children as previously stated, were each examined firstly on a Terman-Merrill L intelligence test with a re-examination on a parallel form - form M, after an interval of not less than six months and not more than two years, and where possible, the original reading and spelling tests were re-administered. On the Laterality tests however, i.e. Performance and Van Riper, together with Eye tests, it was found impossible to examine the total 1044. Accordingly 770 of this Total Group were given these individual Laterality tests. These totals combined - 341 girls and 429 boys, 170 in the Normal Group, 300 in the Twin Group or 150 pairs and 300 in the Retarded Group.

The following figures and data will therefore refer to this Total Laterality Group of 770 subdivided as stated for Normal, Twins and Retarded Groups.

Owing to conditions of testing, e.g. absence of children, the factor of distance etc., this Total Group of 770 children was found to include 120 children whose A.Qs. were over 100 and who were therefore non-retarded. No selection was made in the 770 children who were given the Van Riper beyond the fact that they were members of

the original Total Group of 1044 and had been previously tested. As the children were examined on the Eye Tests they were tested under the heading of RE or righteyed: LE or lefteyed. As they were examined on the Performance and Van Riper Tests, they were classified as RH or righthanded, LH or lefthanded, and ambi or ambihanded.

These categories yielded the classifications -

RHRE or righthanded: righteyed - regarded as a pure dextral.
LHLE or lefthanded: lefteyed - regarded as a pure sinistral.
RHLE or righthanded: lefteyed - regarded as a crosslateral.
LHRE or lefthanded: righteyed - regarded as a crosslateral.
Ambi-LE or ambihanded with left eye dominance.
Ambi-RE or ambihanded with right eye dominance.

These two latter categories were grouped with the respective crosslateral classifications.

The abbreviations in the following pages will refer to these classifications.

(A)

Total Laterality Group.

These children were individually examined on 3 Eye Tests (a) Telescope Eye Preference (b) Ruler Test (c) T-hole Eye Preference. They were each given 3 Performance Tests (a) Hoopla Test (b) Bean Bag Test (c) Peg Board Test, with a Trial Test for each. Finally each child was examined on the Van Riper Critical

Angle Board in its 3 aspects (a) Kinaesthetic (b) Script and (c) Visual.

The results on the performance tests yielded a composite score for preferred and non-preferred hand, while the 3 aspects of the Van Riper test likewise yielded a composite score for mirroring. The hand which mirrored predominantly, revealed the innate handedness of the subject. The preferred hand as shown on the performance tests was carefully compared with the hand revealed as dominant on the Van Riper. Agreement on both types of test was taken as indicative of true handedness. Cases not in agreement were investigated and the handedness determined by results on the Van Riper as the performance tests were more subject to the effects of training and environmental pressure while Van Riper postulates that his test discovers innate handedness.

The results of the three eye tests were studied and cases allocated to right or left eyedness according as the score was 50% + in one direction (3 trials with each eye were given). Thus a child scoring 6/9 with the right eye would be considered in that category while a child scoring 4/9 with the right eye and 5/9 with the left eye would be considered predominantly lefteyed. The higher score indicated the eyedness.

The Performance, Van Riper and Eye tests were then considered together and categories of hand and eye were established. As previously stated six categories were

found - RHRE, RHLE, LHLE, LHRE, Ambi-R and Ambi-L.

Data have been transmuted by previous investigators into indices of handedness which give the percentages of right and left hand preferences and frequency curves for these have been constructed by Durost 1934 (25), Ojemann 1930 (73) Koch 1933 (52) Burt 1937 (11). The latter noted that the curve for handedness is continuous but not symmetrical and that the righthanded group is far larger than the lefthanded group with much overlapping. This tendency can be seen from the Table following.

In the Total Laterality Group the percentages of right and left handed children were calculated, irrespective of the eyedness of the child. Table 19 presents these numbers and percentages.

Table 19

Total Laterality Group.

| | Boys + Girls | | Boys | | Girls | |
|---|---|---|---|---|---|---|
| Hand | No. | % | No. | % | No. | % |
| Right | 540 | 70.12 | 298 | 38.70 | 242 | 31.42 |
| Left | 202 | 26.23 | 115 | 14.93 | 87 | 11.3 |
| Ambi | 28 | 3.63 | 16 | 2.07 | 12 | 1.55 |

The high percentage of righthanded children is noticeable. This high percentage may be an indication of normality or it may reflect a function of age. Previous investigators have postulated an increase in righthandedness with maturity and a decline in lefthandedness with age. The mean chronological age of the righthanded group

approximates to 11.1 years, therefore this group is fairly old and reaching the end of the primary school courses. If as has been postulated, an increase in righthandedness is apparent with maturity, then we can accept higher percentages as a parallel with age, always assuming that an individual matures as he grows older.

The percent of lefthandedness in the group is very high indeed 26.23% for boys + girls. Of this total percentage 14.93% are boys and 11.3% are girls. Thus more of the boys than girls show lefthandedness.

According to Hildreth 1949 (43) the dull and mentally retarded, respond less to social training, receive less of it and do not learn so quickly from incidental clues. Brighter children respond more quickly. If this is so, then the high percentages of lefthandedness associated with immaturity would tend to the suggestion that we are dealing with a group of retarded children. On the other hand, these high percentages may be strongly indicative of the tendency to train children along the conventional path of righthandedness, such that large numbers of innate lefthanders are only 'thrown up' re true handedness, when appropriate tests are used. The finding of more lefthanded boys than girls is in agreement with previous findings as it appears more common with boys than girls. This tendency is maintained when percentages are calculated for the boys group alone and the girls group alone. Brain 1945, reports the trait to be twice as common in males as females. Burt also noted that lefthandedness in Infant schools was twice as common with boys as with girls

but that the sex difference later tended to disappear. Boys appear to outgrow the tendency more readily than girls, or else teachers and parents are less insistent with girls than with boys. It is possible also that boys by virtue of playing more sports where specific handedness is necessary, tend to be more highly trained toward righthandedness. On the first preliminary survey regarding left hand alone, 5.55% were boys and 4.31% were girls, a slight difference showing in favour of the boys. The percentages are smaller. This is interesting in the suggestion it bears that many children may be lefthanded but the tendency is masked and not brought out by observation of writing hand alone. Haefner 1929 (36) considered the handedness of a population of 1144 children whose average age was 11 years and found 6.3% were lefthanded. Of these 6.7% were boys and 6% girls. Ballard in 1911 -12 (5) surveyed 13,189 schoolchildren and found 4.3% lefthanders in a normal population. These findings are considerably lower than found for the present group and, more in keeping with the first preliminary superficial survey of 1044 pupils. The consideration of our Total Laterality Group involves findings for specific types of children namely Dull, Twins and a small Normal Group, but one still associated with the dull group by reason of selection. This may form a partial explanation of the high percentages found. A glance at previous findings for children with low intellectual level reveals surprising accord with the present figures. Wile 1934 (110) investigated children of differing I.Q. gradings

and found with children of I.Q. 50 - 89 that 40% were righthanders and 28% were lefthanders. Ballard (5) found 6.5% of children in Special Schools to be lefthanded while among Normals the percentage was 4.3%. Gordon 1920 (35) examined over 4000 children in schools for the mentally defective and found 18.7% lefthanders as compared with 7.3% among normal children.

The percentage incidences were found for each category of hand and eye for the Total Laterality Group of 770 (see appendix B table 7) and for the subgroups. A high percentage of pure dextrals was found, 42.72% with a percentage of 9.35% for pure sinistrals. The crosslateral percentages combined i.e. RHLE + LHRE showed the high total percentage of 44.28% for all children with 48.24% in the boys group and 39.29% in the girls group: the greater number of cases being found in the RHLE category rather than LHRE. The combined percentage increases when the ambi-R and ambi-L are included. This combined group on first preliminary testing showed a smaller percentage 38.50% with again the majority of the children in the RHLE group. This may be again a reflection on innate handedness which is covered over by righthanded training and thus not easily observed unless appropriate diagnostic tests are used. It has been found by previous writers Hildreth 1949 (43) that from 20 - 40% of the population show mixed dominance depending on the age when the individuals are tested. The percentage of 44.28% of all children in this group

is thus higher than stated. Our percentage may be influenced by the pressure of a large number of dull children, as these types tend to show higher incidence of mixed laterality than normal children. It was found by Burt that among older children and students, less than half of lefthanders were also lefteyed, thus correspondence between eye and hand diminishes with age. Our group may tend to be influenced here also, if one accepts the above hypothesis.

The remaining percentages in the Total Laterality Group reflect 3.62% for all children who are ambidextrous, 2.07% were boys while 1.55% were girls. More boys than girls tended to show this feature although the numbers were not large. It has been claimed that there is no such thing as true ambidexterity, as such people are in reality lefthanders who have gained some skill with the right hand, or righthanders who have cultivated some degree of skill with the left, or individuals who have never achieved manual dominance. Burt and others noticed that what is usually termed 'ambidexterity' is really converted sinistrality frequently found with children who have been partially changed over. It is interesting that more boys than girls showed ambidexterity and likewise lefthandedness appears to be more prevalent with boys than girls. Ambidextrous cases are found more frequently among the mentally retarded and dull than among those of normal intelligence. Burt 1937 (11) thus found ambidexterity to be rare among normal

schoolchildren. Schaefer 1911 (87) reported .021% of 17,074 schoolchildren to be ambidextrous, thus it occurs more rarely than lefthandedness among children. This would appear to agree with theories which postulate dominance as a feature of growth. A child is continually developing towards final dominance and therefore has not had time to establish mature skill with both hands or with one hand such that the other can act as a skilful auxiliary, such as ambidextrous persons show.

(B)

The Subgroups.

The percentage incidences of hand and eye were calculated for each of the subgroups, Twin, Normal and Retarded (see Tables 8 - 10, Appendix B).

In considering the three subgroups an interesting factor emerges that the highest percentage of pure dextrals or righthanded righteyed children appears in the Twin Group, 46.33% with the smallest percentage in the Retarded Group, 39%: with the Normal group falling midway with 42.94%. In each case a higher percentage is found with the girls rather than with the boys.

In considering pure sinistrals, i.e. - lefthanded lefteyed, the same trend emerges. The highest percentage is again with the Twin Group, 11% with a higher percentage of girls than boys. The smallest percentage is with the Retarded Group, 7.66% again a higher percentage of girls

than boys while the Normal Group falls midway with 9.41%. With the Normal Group however, more boys than girls are evident in this category although the numbers in each are small.

With the Twin Group and the Retarded Group a higher percentage of girls than boys appear to be either pure dextral, or pure sinistral. This trend shows itself in the Normal Group with the pure dextrals only, while a higher percentage of boys in the Normal Group appear to be pure sinistral.

By combining the two aspects of crosslaterality, i.e. RHLE + LHRE a total crosslateral picture can be gained for the three groups. The trend of the pure dextral or pure sinistrals is not followed when considering the crosslaterals as the Retarded Group shows the highest total percentage 47.66%. In the boys group are 51.04% of the boys and in the girls group 41.81% of the girls, thus crosslaterality appears more strongly with the boys and in the dull group.

The lowest percentage of crosslaterals lies with the Twin Group where there is found 41%: 45.13% of the boys, and 37.17% of the girls - again a much higher percentage of boys than girls. The Normal Group falls midway with 44.11% with 47.36% boys and 39.99% girls, once more a higher percentage found with the boys.

In considering the combined ambidextrous groups the same trend as in the crosslaterals can be seen. The

highest percentage lies with the Retarded Group, 5.66% with 5.78% among the boys and 5.44% among the girls. The lowest percentage is in the Twin Group, 1.66% of which 1.38% are boys and 1.91% girls; while the Normal Group appear midway with 3.52% for all the children of which 3.15% are boys and 4% are girls. The very few in this category influence the percentage.

The different trend of crosslaterals and pure dextrals or pure sinistrals is interesting in that more boys than girls appear to suffer from indefinite dominance or lack of correspondence of hand and eye. Is this due therefore to interference with the natural handedness of boys and emphasis on righthand training creating shifthand cases? When one considers the total retardation situation where boys are significantly poorer than girls, this mixed laterality may be exerting a strong influence. This will be investigated in later chapters. It is also of interest that the Twin Group shows the highest percentage for pure dextrals and sinistrals and the lowest percentage for crosslaterals with the lowest combined percentages for ambidexterity. This suggests that this group of Twins are definitely right or lefthanded, with less confused laterality when compared with the Retarded and Normal Groups. It may be that parents accept the fact that one twin is the counterpart of the other whether this is so or not and do not, to the same extent, expect that both should be righthanded. It may therefore point to relaxed pressure in changing over hands where twins are regarded as specifically different from siblings. It might also mean

that this group of twins are for the most part, not identical or that twinning occurred after the primordia of hand and eye had been established.

With the Normal Group as with the Retarded, a higher percentage of mixed laterality appears. Does the average child then, and more particularly the dull child, suffer adversely, and more than a twin, in that social convention expects righthanded conformity? Or is confused laterality more characteristic of the dull child or more difficult for the dull child to overcome? These questions remain to be investigated in later chapters. The percentages of ambidexterity are interesting in that the trend tends to reveal a higher amount with the Retarded Group. Is this lack of dominance more characteristic of the slower maturing child? There is strong suggestion that this would appear so.

Groups with Non-Retarded Withdrawn.

From among this Total Laterality Group of 770 it was found on studying the Accomplishment Quotients that 120 of these children were not retarded by the criterion of A.Q. less than 100. These 120 children were subtracted from the Total Group and respective subgroups and formed a group by themselves. The figures and percentages for each group were then calculated with the non-retarded children withdrawn to see if there was any appreciable difference in any category.

The tables with figures and percentages for the Total

Group less 120 non-retarded and for each subgroup with the respective numbers withdrawn can be found in Appendix B, Tables 11 - 14.

In considering the percentages for the Total Group minus the non-retarded, little change is seen from the percentages previously given. The percentage for the total righthanded righteyed group increases .88% when the non-retarded are withdrawn. The percentage for the total crosslateral groups when combined rises by .02% while the pure sinistral group falls slightly by .74%. The ambi groups combined likewise fall by .40%. The general trend of the two Total Groups remains the same as before with the highest percentage among the crosslaterals and the righthanded righteyed groups.

In considering the subgroups the percentages of the Retarded Group remain very similar although 24 children were withdrawn as being non-retarded.

In the Normal subgroup a slight rise of .44% is seen in the RHRE group with children withdrawn. Likewise in the crosslateral groups combined, a rise of 1.46% is perceptible. The pure sinistral group falls slightly in the new group by 1.33% as do the combined ambi groups by .59% There were 34 children withdrawn from the Normal Group as being non-retarded.

In the Twin subgroup a rise of 3.24% is seen in the new percentages for righthanded righteyed children with a slight decrease for the crosslateral groups of 1.52%. A

fall is also seen in the pure sinistrals, i.e. the lefthanded lefteyed group, which drops by 1.34%, while the combined ambi groups show a decrease of .40%. There were 62 children among the twins who were non-retarded. The differences in percentages in the Twin subgroups may be due to the larger number withdrawn.

In general over the three subgroups the trend remains similar and is little affected by the number withdrawn.

Thus 8% of the Final or Retarded Group were withdrawn while 20% of the Normal Group and 20.6% of the Twin Group were found to be non-retarded by our criterion of A.Q. below 100.

(C)

The Non-retarded Group.

This non-retarded group were considered by themselves and the numbers and percentages in each hand-eye category were calculated. The table presenting these figures can be found in Appendix B, Table 15.

It is interesting that the Mean 2nd I.Q. for this group is 87.16 while the Mean 2nd A.Q. is 107.66.

Thus the non-retarded group as a whole is one of 'dull' children who are working 'well to' and 'above' capacity. In this group 71 are girls and 49 boys. Thus more dull girls than dull boys in this group are achieving at mental level.

In considering the percentages of the group of non-

retarded children observation confirms the fact that similar trends can be seen as were noted in the retarded subgroups. Again the highest percentage for all children lies in the crosslateral groups combined 44.16%. This is similar to the percentage found in the crosslaterals in the retarded group. A further high percentage can be seen in the righthanded, righteyed group with a very high percentage among the pure sinistrals, i.e. lefthanded, lefteyed, 13.33%. Likewise a combined ambi group shows 5.82% non-retarded. Contrary to previous findings therefore a high percentage of lefthanded and lefteyed children can be seen to be non-retarded. Likewise a similar high group of crosslateral children do not appear to be suffering adversely in their attainment.

From these percentages there does not appear to be any great difference in the laterality trend of the retarded groups and the laterality trend of the non-retarded both showing similar features.

Similar findings are also reported by Witty and Kopel 1936 (115). In investigating the laterality characteristics of poor readers, they found a higher percentage of righthanders among their retarded cases with a lower percentage of lefthanders. Likewise with eyedness they found that lefteyedness operated equally with good and bad readers. They found no relationship between reading ability and various combinations of hand and eye and came to the conclusion that conditions of

crosslaterality or mixed dominance occur no more frequently in a problem group than in a non-problem group. Likewise Gates and Bond, 1936 (27) in testing the laterality of retarded readers with a normal control sample came to the conclusion that eye and hand dominance have little to do with reading difficulties as their data among normal readers and older reading problem cases showed no consistent trend in laterality.

Other investigators, Woody and Phillips 1934 (117) Kirk 1934 (51) and Teegarden reached the same conclusion.

In order to investigate this problem further and to study the significance of laterality on the intelligence and achievement of the Total Laterality Group with sub-groups, the Mean Intelligence Quotient and Mean Accomplishment Quotient with the Standard Deviation of the Mean was calculated for each group under the various classifications of hand and eye. This will be considered in the next chapter.

(D)

Eyedness of the Total Laterality and Subgroups.

The eyedness of the group of 770 children was examined by means of three tests. (a) Telescope Eye Preference (b) T hole Eye Preference and (c) Ruler Test. Three trials were given on each of these three tests. Nine records were thus available on the eyedness of the children. They were considered as being only right or

lefteyed, thus a score of R 6/9 was interpreted as inclining to the right eye and the child was placed in the category of righteyed or vice versa with a score L 6/9. The percentages were then calculated for the Total Group and for the Subgroups of Retarded, Normal and Twin. Table 20 expresses the percentage for the Total Laterality Group of 770 children and the Subgroups.

Table 20.

Total Group.

| | Number | Percentage |
|---|---|---|
| Righteyed | 475 boys + girls | 61.68% |
| Lefteyed | 295 boys + girls | 38.31% |

Retarded Group. N = 300

| | Number | Percentage |
|---|---|---|
| Righteyed | 174 boys + girls | 58% |
| Lefteyed | 126 boys + girls | 42% |

Normal Group. N = 170

| | Number | Percentage |
|---|---|---|
| Righteyed | 107 boys + girls | 62.9% |
| Lefteyed | 63 boys + girls | 37% |

Twin Group. N = 300

| | Number | Percentage |
|---|---|---|
| Righteyed | 194 boys + girls | 64.6% |
| Lefteyed | 106 boys + girls | 35.3% |

These percentages are very similar to those obtained on the first preliminary testing when a single cylinder test was used. This may be due to the fact that the ultimate eye tests were similar to the cylinder in that the child 'looked through' at an object. It would seem

thus that to establish a definite right or left eyedness, one type of test obtains as valid an estimate as several of the same type. These eye tests do not however measure the degree of eyedness but for the purposes of this study this was not required. The righteyed from these Total percentages are almost twice as frequent as the lefteyed in a group of 770.

With the subgroups of Retarded, Normal and Twins, again the percentage of righteyed is greater than for lefteyed.

With these subgroups the highest percentage of lefteyed children is in the Retarded Group, where also therefore the smallest percentage of righteyed children are found. This finding of lefteyed children in the Retarded Group is similar to the finding on first testing when 520 Retarded children were examined. It may therefore be that in the later selection from the original group many righteyed children were omitted, or it may also be that lefteyedness characterises this group of dull children. The Normal group shows a rise in lefteyedness from first preliminary observation but the Twin group shows a slight decrease when compared with the first eye test.

The percentages on the two series of testings however are sufficiently alike to justify a claim of having gauged the pattern of eyedness in this group of 770 children when right and left eyedness only is considered.

Comparisons with earlier investigators, suggest similar percentages e.g. Parson 1924 (77) reported 69.3% righteyed and 29% lefteyed in his investigation. The larger

percentage of lefteyedness in the present group may be influenced by the fact that no ambi-eyed cases were considered.

A.M. and M.A. Snyder 1928 (96) report that on an average 64% of people have a right monocular preference and 21% have a left monocular preference. They also believe that eye preference is an acquired visual habit, is modifiable and varies in degree with age. If this is so, then many of the present group would appear to have acquired left eye visual habits as the percentage of left-eyed is greater than that found by A.M. and M.A. Snyder. This assumption is difficult to justify. If the habit is modifiable and can vary with age then it would seem possible that with increased maturation lefteyedness should decrease and righteyedness become stronger as more training is established towards 'right' orientation. This does not appear to follow with our present group. Further, the high percentage of lefteyedness may agree with the theory that we have present, children who are pure sinistrals but who have been trained to use the right hand. It was observed that most of the crosslateral cases fell in the righthanded left-eyed group. Thus the higher percentages of lefteyedness found may reflect true sinistrality which has become 'crossed' as a result of hand training. The lefthanded righteyed group may contain ambi-eyed children who are at present hidden by our method of selection.

Lund 1932 (58) with certain monoptometer tests found a figure of 69.8% for righteyed persons, 25.5% for lefteyed and

4.6% ambiguous in eyedness.

Later investigators have tended to the viewpoint that lefthanded people are evenly divided between left and right eye dominance, whereas the majority of righthanders are clearly righteyed. A high percentage of righthanders has been found for this total laterality group. Thus an equally high percentage should be righteyed if the viewpoint is accepted that righthandedness tends to be an indication of strong dextrality with reference to eyedness.

## Summary of Laterality Characteristics of the Groups.

In the Total Laterality Group many more righthanded than lefthanded children are found.

Higher percentages of lefthanders found than in previous investigations. More lefthanded boys than girls observable.

High percentages can be observed in crosslateral categories with more boys than girls: a higher percentage with the RHLE group than LHRE group is present, suggesting hidden lefthandedness or the presence of a shifted sinistral group.

A very small percent of ambidextrous children is found which is in agreement with the findings of previous investigators.

More boys than girls appear to suffer from indefinite dominance or lack of correspondence of hand and eye.

The Retarded or Dull group of children appear to show most indefinite dominance. The Twin group do not appear to show such indefinite dominance.

Little change is seen in the groups or laterality trends when the Non-retarded are withdrawn.

The Non-retarded group when considered by themselves, show similar trends in laterality to the total laterality group. The non-retarded group is a dull group and may therefore be reflecting trends similar to a dull group of children (e.g. Retarded).

The eyedness of the respective groups agree with previous investigators. The trends of eyedness agree with eye testing on first occasion.

## References.


25. Durost W.N. - 1934. The Development of a battery of objective group tests of manual laterality with the results of their application to thirteen hundred children. Genet. Psychol. Monog. 1934 - 16, 225 - 335.

73. Ojemann R.H. - 1930. Studies in Handedness. J. Educational Psychology - 1930, 21, 597 - 611, 695 - 702.

52. Koch H.L. - 1933. A study of the nature, measurement and determination of hand preference. Genet. Psychol. Monog. 1933 - 13, 117 - 218.

11 Burt C. - 1937. The Backward Child. MacMillan New York.

7. Brain W.R. - 1945. Speech and Handedness. The Lancet. Vol. 249, 837 - 841.

36. Haefner R. - 1929. Educational significance of lefthandedness. Contributions to Education No. 360. New York Bureau of Publications. Teachers' College Columbia University. 1929.

5. Ballard P.B. - 1911 - 12. Sinistrality and Speech. J. of Exper. Ped. 1911-12, 1, 298 - 310.

43. Hildreth G.H. - 1949. The Development and Training of Hand Dominance. J. Genet. Psych. 1949 - 75, 1950 - 76.

87. Schaefer N. - 1911. Die Linkshänder in der Berliner Gemeindeschulen. Berliner Klin. Wochensch. 1911 - 48, No. 7.

77. Parson B.S. - 1924. Left-handedness. New York MacMillan.

96. Snyder A.M. and M.A. - 1928. Eye Preference tendencies. J. of Educational Psychology 1928 - 19, 431 - 433.

58. Lund F.H. - The Monoptometer. A new device for Measuring eye dominance. American Journal of Psychology. 1932 - 44, 181 - 183.

110. Wile I.S. - 1934. Handedness. Right and Left. Boston, Lothrop Lee and Shepard, 1934.

35. Gordon H. - 1920. Lefthandedness and mirror writing, especially among defective children. Brain 1920. 43, 313 - 368.

95. Smith L.G. - 1917. A brief survey of right and left handedness. J. Genet. Psychology, 1927 - 24.

115. Witty P.A. and Kopel D. - 1936. Sinistral and mixed manual ocular behaviour in reading disability. J. of Educational Psychology 1936 - 27, 119 - 134.

27. Gates A.I. and Bond G.L. - 1936. Relation of Handedness, Eyesighting and Acuity Dominance to Reading. J. Educational Psychology 1936 - 27, 450 - 56.

51. Kirk S.A. - 1934. A Study of the relation of Ocular and Manual Preference to mirror reading. J. Genet. Psychology, 1934. 44.

117. Woody C. and Phillips A.J. - 1934. The effects of handedness on reversals in reading. J. Educ. Res. 1934. 27.

## Chapter 6.

### (A)

### Analysis of Laterality Characteristics of the Normal Group in Relation to Ingelligence and Achievement of the Group.

In the Normal group were 170 children who were given the Laterality tests of Hand and Eye. There were 95 boys and 75 girls in the group.

As observed in the Table 9 Appendix B which shows the percentage incidences of categories of hand eye, 42.94% of the group were found to be righthanded righteyed. Pure sinistrals yielded 9.41%; combining the sinistrals and dextrals, 52.35% of this group showed coincidence of hand and eye. Percentages of coincidence of hand and eye previously found with Normal populations have been reported as 73.5% Parson (77) 58.9% Cuff (16) 63.4% Miles (65) 56.0% Hildreth (41) 60.0% Schonell (88) 75% Dart (21) and 73% Quinan (79). Our total percent is smaller but near the range established for normality, and is influenced by the small numbers in the group and likewise by the high percentage of crosslaterality 44.11% found in the group. Low percentages of hand and eye agreement have been reported in investigations of subnormal individuals e.g. Mintz 1947 (67) Quinan 1930 (79) and Bryngelson 1940 (9) have found thus. The percentage of 52.35% is sufficiently high to establish the group as

normal in characteristics of coincidence of hand and eye.

Apart from observing the incidence of hand and eye among the groups it was necessary to measure the influence if any, which laterality characteristics showed with reference to intelligence and achievement. Accordingly the intelligence level of the Normal Laterality Group was found.

The distribution of the 2nd Intelligence Quotients was drawn and the means calculated separately for Boys and for Girls.

For boys the mean 2nd I.Q. = 104.77
S.D. = 1.75

For Girls the mean 2nd I.Q. = 100.53
S.D. = 1.82

The mean Intelligence of the group is thus established at the average with a slightly higher level for the boys.

Fig. 16 presents the Distribution of the 2nd I.Qs. separately for Boys and Girls.

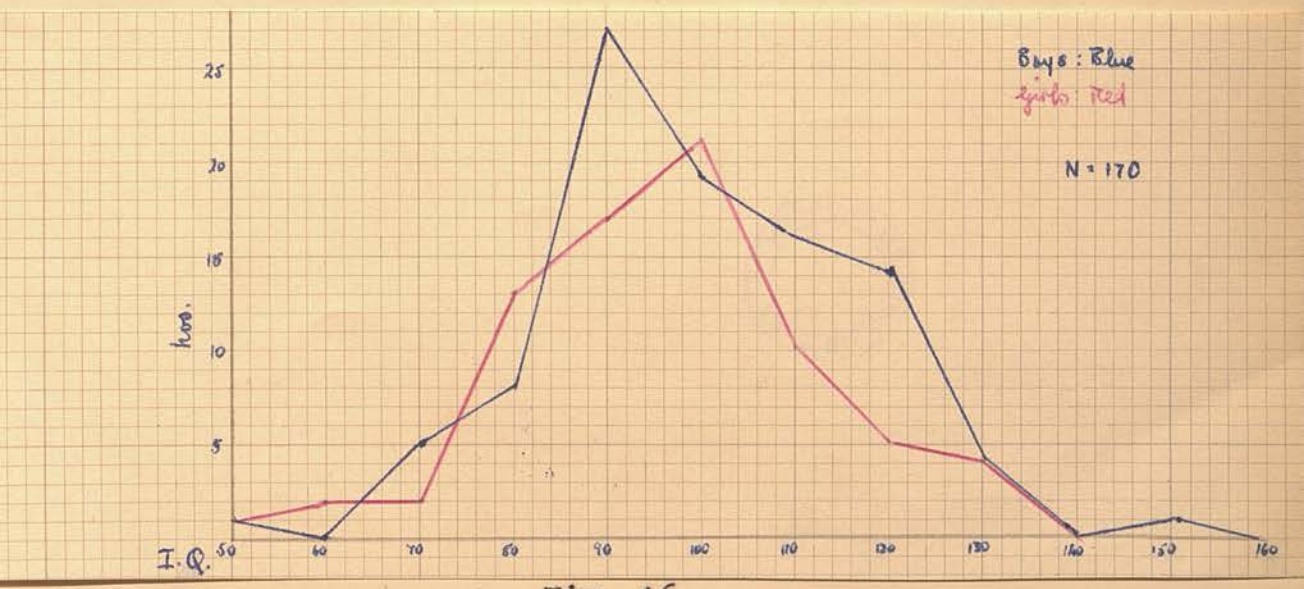



Fig. 16
Distribution of 2nd Intelligence Quotients Boys and Girls of Normal Group.

From the Polygon it can be seen that the range of intelligence for the Boys is wider with more boys than girls in the upper reaches of the scale with a slightly wider scatter below 70 I.Q. for the Girls.

In examining the intelligence with categories of hand and eye and to establish any significant difference in the intelligence of the different categories, the group of 170 were divided into their respective hand and eye classifications i.e. RH/RE LH/RE etc.

The group was then considered in terms of the respective categories of hand and eye. The Mean Intelligence Quotient and Standard Deviation was calculated for each category and for Boys and Girls separately.

Table 21 gives the means and standard deviations of the various hand-eye categories of Boys and of Girls for 2nd I.Q.

Table 21.

| Category | RHRE | RHLE | LHRE | LHLE | Ambi-R | Ambi-L |
|---|---|---|---|---|---|---|
| Boys Mean | 105.64 | 104.72 | 109.75 | 93.64 | 104.0 | 111.5 |
| S.D. | 2.73 | 2.78 | 4.06 | 6.84 | | |
| Girls Mean | 102.41 | 96.00 | 105.07 | 98.60 | 83.7 | - |
| S.D. | 2.79 | 2.5 | 4.75 | 6.25 | | |

All Boys: Mean 2nd I.Q. 104.77 S.D. 1.75
All Girls: Mean 2nd I.Q. 100.53 S.D. 1.82

In each category, with the exception of the lefthanded lefteyed group the girls show lower means than the boys and in accordance with the lower total mean I.Q. for girls compared with the boys of this Normal group.

## Hand

The influence of 'Hand' alone was then considered to find if the group differed significantly because they were, e.g. righthanded or left. Did the hand exercise a marked effect in relation to intelligence and if so, was it more significant for boys or for girls?

In order to establish the significance of 'hand' alone, the means were calculated for all righthanded boys and girls separately. Table 22 shows the means and standard deviations for right and lefthanded boys and girls.

Table 22.

Means and S.Ds. for Right and Lefthanded Boys and Girls.

| Category | | Right Hand | Left Hand |
|---|---|---|---|
| Boys | Means | 105.23 | 103.19 |
| | S.D. | 1.94 | 3.92 |
| Girls | Means | 100.47 | 103.37 |
| | S.D. | 2.11 | 3.84 |

The difference between the means of these groups was tested by the t-test, when the righthanded group was compared with the lefthanded group. The results are -

| | | RH. with LH. |
|---|---|---|
| t-values. | Boys | .521 |
| | Girls | .688 |

The values are not significant. It seems unlikely therefore, that handedness has much effect on the intelligence of the boys or girls in this group.

## Eye.

To establish the significance of 'Eye' alone and to investigate whether righteyed or lefteyed children in the Normal Group differed in any marked way, in intelligence, the means and standard deviations for all righteyed boys and girls were calculated, also for all lefteyed boys and girls separately.

The following table shows the means and S.D. for right and lefteyed boys and girls.

Table 23.

Means and S.Ds. for Right and Left Eyed Boys and Girls.

| Category | | Right Eye | Left Eye |
|---|---|---|---|
| Boys | Mean | 106.85 | 102.14 |
| | S.D. | 2.22 | 2.76 |
| Girls | Mean | 102.06 | 96.62 |
| | S.D. | 2.34 | 2.34 |

The righteyed were then compared with the lefteyed to test for significance of 'eye' alone with intelligence.

| | | Righteyed with lefteyed. |
|---|---|---|
| t-values. | Boys | 1.345 |
| | Girls | 1.349 |

The values are not significant.

It seems unlikely therefore that 'eyedness' has much effect on the intelligence of this group.

## Crosslaterals.

The influence of the crosslateral group was estimated by combining the two respective categories,

i.e. RHLE and LHRE, and the mean I.Q. found with the standard deviation of the mean for boys and girls separately.

Table 24 presents the data.

Table 24.

Means and S.Ds. of the

Crosslateral Categories for Boys and Girls.

| Category | | RHLE + LHRE | Category | | LHRE + RHLE |
|---|---|---|---|---|---|
| Boys | Mean | 106.51 | Girls | Mean | 100.23 |
| | S.D. | 2.30 | | S.D. | 2.67 |

In order to assess the influence of the crosslaterals it was necessary to compare them with a 'pure' group, i.e. a group containing no crosslaterals or ambi cases. Accordingly the Pure Dextrals i.e. RHRE children were combined with the Pure Sinistrals, i.e. LHLE children to form a 'pure' group. The mean I.Qs. and standard deviations were then found for boys and girls separately in this pure group.

Table 25 presents this data.

Table 25.

Means and S.Ds. of 'Pure' Group for Boys and Girls.

| Category | | RHRE + LHLE | Category | | RHRE + LHLE |
|---|---|---|---|---|---|
| Boys | Mean | 102.83 | Girls | Mean | 101.95 |
| | S.D. | 2.70 | | S.D. | 2.55 |

The difference between the means of the crosslateral boys and girls was then compared with the means of the 'pure' group boys and girls.

t-values for 2nd I.Q. of the Crosslateral with Pure Group are -

| | | |
|---|---|---|
| t-values | Boys | 1.033 |
| | Girls | .456 |

The difference is not significant.

It would appear therefore that the influence of mixed hand and eye in this Normal Group on intelligence is no more marked than the influence of coincidence of hand and eye.

Finally the two types of crosslaterals were compared with each other to assess whether being righthanded and lefteyed had more significance for intelligence than being lefthanded and righteyed. This was considered for boys and girls.

Table 26 presents the data.

Table 26.

Means and S.Ds. of Crosslateral Categories.

| | | RHLE | | | LHRE |
|---|---|---|---|---|---|
| Boys | Mean | 104.72 | Boys | Mean | 109.75 |
| | S.D. | 2.78 | | S.D. | 4.06 |
| Girls | Mean | 96.00 | Girls | Mean | 105.07 |
| | S.D. | 2.5 | | S.D. | 4.75 |

The difference between the means as tested by the t-test yielded the values -

| | | RHLE with LHRE |
|---|---|---|
| t-values. | Boys | 1.045 |
| | Girls | 1.752 |

The differences are not significant.

It appears therefore that no significance emerges

with reference to whether a boy or girl is of mixed hand and eye in either order of RHLE or LHRE.

None of the foregoing values are significant for the respective groups. It seems unlikely therefore that handedness or eyedness has much effect on the intelligence of this group.

## Laterality and Achievement.

It was necessary to estimate the effect of laterality on the performance of the children in their reading and spelling tests. The Accomplishment Quotient was therefore used as before.

The distribution of the 2nd Accomplishment Quotient for the total Normal Laterality Group N = 170 is presented in Fig. 17 for boys and girls separately.

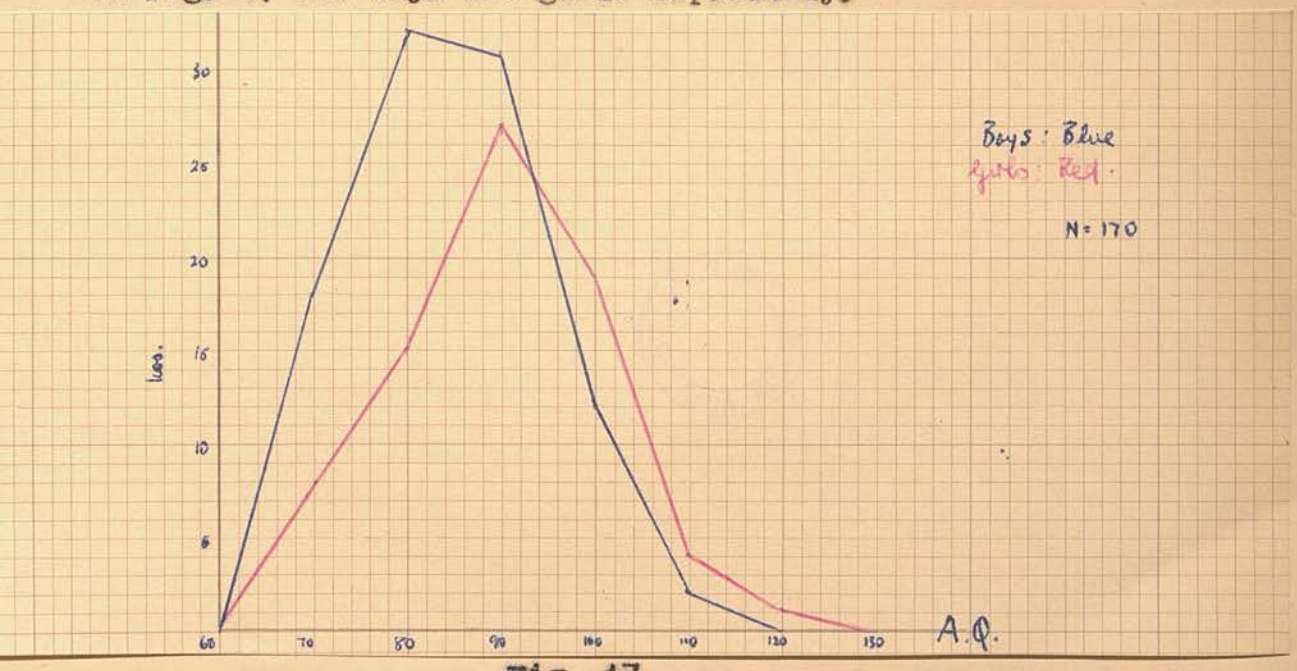



Fig. 17.

Distribution of 2nd A.Qs. for boys and girls separately.
Normal Group N = 170.

For boys alone the Mean 2nd A.Q. = 88.77
S.D. = .94

For girls alone the Mean 2nd A.Q. = 94.40
S.D. = 1.28

Hence the girls appear to be working at a slightly higher level than the boys.

As with the Intelligence Quotient the various categories of hand and eye were surveyed and the mean and standard deviation of the mean computed for each category. Table 27 presents the means and S.Ds. of the 2nd Accomplishment Quotient for the various categories of hand and eye and for boys and girls separately.

Table 27.

Means and S.Ds. of 2nd A.Q. for Various Categories.

Boys and Girls.

| Category | | RHRE | RHLE | LHRE | LHLE | Ambi-R | Ambi-L |
|---|---|---|---|---|---|---|---|
| Boys alone | Mean | 88.14 | 89.38 | 87.75 | 90.09 | 94.0 | 89.5 |
| | S.D. | 1.54 | 1.84 | 2.37 | 3.55 | | |
| Girls alone | Mean | 95.43 | 97.75 | 86.00 | 100.40 | 93.0 | |
| | S.D. | 1.87 | 2.99 | 1.81 | 4.81 | | |

All Boys Mean 2nd A.Q. = 88.77
S.D. = 0.94

All Girls Mean 2nd A.Q. = 94.40
S.D. = 1.28

## Hand

In order to establish the significance of the 'hand' alone as it was associated with Achievement, the mean of

the 2nd A.Q. and Standard Deviation was found for all righthanded and lefthanded boys, irrespective of eye. Similarly such measures were calculated for all righthanded and lefthanded girls.

Table 28 presents the means and S.Ds. of the categories of hand.

Table 28.

The means and S.Ds. of right and lefthanded boys and girls.

| Category | | Right Hand | Left Hand |
|---|---|---|---|
| Boys | Mean | 88.69 | 88.70 |
| | S.D. | 1.18 | 1.98 |
| Girls | Mean | 96.13 | 89.79 |
| | S.D. | 1.58 | 2.31 |

Eye.

To establish the significance of the 'Eye' alone, the means and standard deviations for all righteyed boys and girls were calculated and also for all lefteyed boys and girls separately.

Table 29 presents these figures for the 2nd A.Q.

Table 29.

Means and S.Ds. for right and lefteyed boys and girls.

| Category | | Right Eye | Left Eye |
|---|---|---|---|
| Boys | Mean | 88.13 | 89.57 |
| | S.D. | 1.26 | 1.60 |
| Girls | Mean | 92.85 | 98.38 |
| | S.D. | 1.51 | 2.51 |

## Crosslaterals.

The mean accomplishment quotients and standard deviations were found for the crosslaterals, by combining the two groups, i.e. RHLE + LHRE for boys and girls separately, in order to study the significance.

Table 30 presents these measures for boys and girls.

Table 30.

Crosslaterals (Groups combined) for 2nd A.Q.

| Category | | RHLE + LHRE | | | |
|---|---|---|---|---|---|
| Boys | Mean = | 88.80 | Girls | Mean = | 92.97 |
| | S.D. = | 1.44 | | S.D. = | 2.08 |

Finally a 'pure' group was obtained by combining the Pure Dextrals, i.e. RHRE children with the Pure Sinistrals, i.e. LHLE. These formed a group excluding crosslateral and ambi cases, hence were classified as 'pure'. Table 31 presents the measures for this group of means and S.D. of the means on 2nd A.Q.

Table 31.

Pure Group - 2nd A.Q.

| Category | | RHRE + LHLE | Category | | RHRE + LHLE |
|---|---|---|---|---|---|
| Boys | Mean | 88.60 | Girls | Mean | 96.02 |
| | S.D. | 1.43 | | S.D. | 1.75 |

Table 32 presents the data when the crosslateral categories are considered separately.

Table 32.

Crosslaterals - 2nd A.Q.

| Category | | RHLE | Category | | LHRE |
|---|---|---|---|---|---|
| Boys | Mean | 89.38 | Boys | Mean | 87.75 |
| | S.D. | 1.84 | | S.D. | 2.37 |
| Girls | Mean | 97.75 | Girls | Mean | 86.00 |
| | S.D. | 2.99 | | S.D. | 1.81 |

The difference between these groups of means was tested by the t-test. The righthanded group was compared with the lefthanded group to test the significance of the 'hand' alone. The righteyed group was compared with the lefteyed group to test the significance of eye alone with achievement.

The crosslateral group was then compared with the 'pure' group to test the significance of the pure dextrals and sinistrals with those of crossed hand and eye and the possible effect on achievement.

Finally the two groups of crosslaterals were compared with each other to establish which showed more significance,

i.e. RHLE or LHRE.

These comparisons were made in every case for boys and girls separately.

Table 33 presents the t-values of the different categories.

Table 33.

| Category | RH with LH | RE with LE | Pure with Cross | RHLE/LHRE |
|---|---|---|---|---|
| Boys | .005 | .718 | .101 | .537 |
| Girls | 2.127$^{x}$ | 1.349 | 1.384 | 3.243$^{xx}$ |

Two only of these values are significant.

With girls in comparing the effect of right hand with left hand there is a significant value of 2.127 at the .05 level in favour of the right hand as against lefthanded girls. Likewise with the crosslateral categories, with girls also, there is a value of 3.243 significant at the .01 level which suggests that the RHLE group tend to be doing better work than the LHRE girls.

There does not appear to be any significant relationship with boys. Thus one may conclude that with boys, in the Normal group hand and eye do not appear to be significantly affecting their achievement. With girls the influence is seen with the right hand and more significantly with the right hand left eye group.

It would appear therefore that girls whose native handedness is right may be experiencing less difficulty than those whose natural pattern is reversed, as they are achieving at a higher level than lefthanded girls.

Likewise with the crosslateral groups it is possible that the influence of the hand is outweighing the counter tendency of the eye with RHLE groups. With the LHRE group the natural perception of righteyedness is not sufficient to outweigh the handicap of reversed handedness.

Summary of Laterality Characteristics of Normal Group.

The percentage found for children showing coincidence of hand and eye is similar to that found for Normal Groups.

The Mean Intelligence Level of the Group is established at average grading for both boys and girls.

The influence of handedness for boys and girls is not significant for intelligence.

The influence of eyedness for boys and girls is not significant for intelligence.

The influence of mixed hand and eye or coincidence of hand and eye is not significant for intelligence.

The influence for types of crosslaterality alone is not significant for intelligence.

The Mean Accomplishment Quotient for boys and girls is established below average with girls working at a higher level than boys.

The influence of hand, eye, crosslaterality and coincidence of hand and eye is not significant for achievement with the exception of right handedness with the girls and again with the crosslateral category of RHLE with the girls - these two categories of girls appear to be

doing better work than the lefthanded girls or the lefthanded righteyed girls.

## References.


77. Parson B.S. - Left Handedness. New York. MacMillan 1924.

16. Cuff N.B. - The Interpretation of Handedness. J. of Experimental Psychology 1928. - 11, 27 - 39.

65. Miles W.R. - Ocular Dominance demonstrated by unconscious sighting. J. of Experimental Psychology 1929 - 12, 113 - 126.

41. Hildreth G. - A School Survey of Eye Hand dominance. J. of Applied Psychology, 1945 - 29, 83 - 88.

88. Schonell F.J. - The Relation of Reading Disability to Handedness and Certain Ocular Factors II. British Journal of Educational Psychology 1940 - 103, 1941 - 11,1.

21. Dart C. - Eye, hand and foot preferences of mentally subnormal subjects compared with individuals of normal and superior intelligence - Journal of Juv. Res. 1938 - 22, 119 - 122.

79. Quinan C. - The principal sinistral types. Archives of Neurology and Psychiatry, 1930 - 24. 35 - 47.
(Also) The Handedness and eyedness of speeders and of reckless drivers. Archives of Neurology and Psychiatry, 1931 - 25, 829 - 837.

9. Bryngelson B. - A Study of Laterality of Stutterers and Normals. Journal of Social Psychology, 1940 - 11, 151 - 155.

67. Mintz A. - Lateral preferences of a Group of Mentally subnormal Boys. J. Genet. Psychology, 1947 - 71, 75 - 84.

## Chapter 6.

(B)

## Analysis of Laterality Characteristics of Retarded Group in Relation to Intelligence and Achievement.

In the Retarded Group to which laterality tests were given were 300 children, 190 boys and 110 girls. These children were examined on hand and eye tests and the final numbers and classifications in each category are given as in Table 8 Appendix B.

This group is characterised by a high percentage of crosslateral cases and relatively high percentage of ambi-handed cases with a small percentage of pure sinistrals when compared with the Normal Group.

The small percentage of pure sinistral children is not in keeping with the findings of Gordon 1921 (35). He found that the percentage of lefthanded children was much higher in schools for the mentally defective than in normal schools: the percentage in the latter approximated to 7.3% while in schools for defective it rose to 18.2%. The finding of more pure sinistral girls than boys is however in agreement with Gordon who stated that the percentage of lefthanded girls is 25% higher than that of lefthanded boys. This Retarded Group is not one of defective children but dull - an intermediate grading from defective to normal.

If however one regards the cases of mixed hand and eye as being cases of shifted sinistrality then the total

percentage for this group is very high indeed and the hand and eye characteristics are in keeping with the general findings. Mintz 1947 (67) in his study of 97 boys from a New York institution for the feebleminded, I.Qs. ranging from 47 to 87, found 15.5% of his subjects were predominantly lefthanded. Reported percentages of lefthandedness in a normal population are found generally between 4 and 9%. Mintz found in categories of hand and eye that 38.7% were pure dextral cases which is very similar to the percentage of 39% found with this group: 40% were crosslateral righthanded lefteyed, a higher percentage than 31.33% found with this group. Mintz found a smaller percentage of crosslateral lefthanded righteyed children compared with normal groups. Likewise he found relatively few in his group with concordant hand and eye preference which is also in keeping with the high percentage of mixed hand and eye cases in this group. This would appear to be a feature of cases subnormal in intelligence. While the excess of lefthanded children and sinistrality may be attributed to instances of disease of the central nervous system as Gordon suggests, much research on distributions of hand and eye preference in family patterns of subnormal subjects will be necessary before the role of heredity in mental defect can be firmly established. If it were found that subnormal children differed in any marked degree from their parents then new techniques for the study of non-hereditary cases of defect

would be required, as Gordon's hypothesis would be proved.

In order to study the significance of the laterality characteristics of this group on their Intelligence and Achievement the mean 2nd Intelligence Quotient was calculated for the group with the Standard Deviation, for boys and girls separately. Results are as follows:-

| | | |
|---|---|---|
| Mean 2nd I.Q. for boys alone | = | 83.61 |
| S.D. | = | 0.91 |
| Mean 2nd I.Q. for girls alone | = | 83.33 |
| S.D. | = | 1.27 |

The boys and girls are thus of the same level of intelligence at a dull grading, with slightly wider range among the girls in the top categories.

In Fig. 18 is presented the 2nd Intelligence distribution for boys and girls separately.

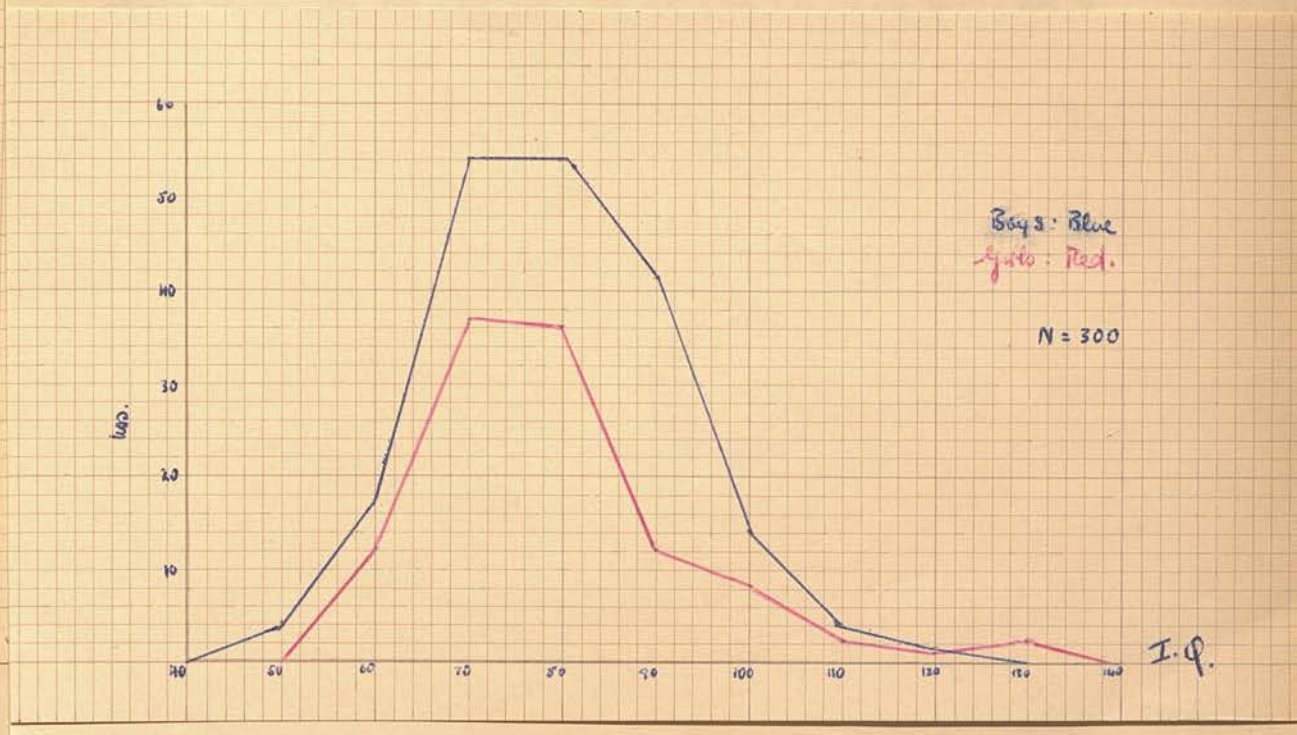



Fig. 18.

Distribution of 2nd I.Q. Boys and Girls separately.
Retarded Laterality Group.

In order to establish the significance of the various categories of hand and eye on intelligence the Retarded Group was examined in its respective classifications and the mean Intelligence Quotient and Standard Deviation of each category was calculated. Table 34 shows the means and S.Ds. of the 2nd I.Q. for the various categories of hand and eye - RHRE, RHLE, LHRE, LHLE, Ambi-R, Ambi-L, for boys and girls separately.

Table 34.

2nd I.Q. Means and S.Ds.

| Category | | RHRE | RHLE | LHRE | LHLE | Ambi-R | Ambi-L |
|---|---|---|---|---|---|---|---|
| Boys | Mean | 84.70 | 83.15 | 83.88 | 81.15 | 83.8 | 79.7 |
| | S.D. | 1.72 | 1.42 | 2.09 | 4.19 | | |
| Girls | Mean | 81.08 | 81.90 | 86.56 | 82.40 | 113.3 | 89.3 |
| | S.D. | 1.23 | 2.67 | 3.33 | 3.01 | | |

(Retarded Group) - All Boys Mean 2nd I.Q. = 83.61
S.D. = 0.91

All Girls Mean 2nd I.Q. = 83.33
S.D. = 1.27

Hand.

In order to study the significance of 'hand' alone on intelligence i.e. to ascertain whether righthanded boys and girls had higher intelligence than lefthanded boys and girls in the Retarded Group or vice versa, the means and standard deviations were calculated for all righthanded boys and girls and for all lefthanded boys and girls. These were calculated separately.

Table 35 shows the means and S.Ds. for right and

lefthanded boys and girls.

Table 35.

| Category | | Right hand | | Left hand |
|---|---|---|---|---|
| Boys | Mean | 83.95 | Mean | 83.11 |
| | S.D. | 1.12 | S.D. | 1.77 |
| Girls | Mean | 81.40 | Mean | 84.96 |
| | S.D. | 1.27 | S.D. | 2.35 |

The righthanded were then compared with the lefthanded by means of the t-test. This was done for boys and girls.

t-values for 2nd I.Q. are:

| | |
|---|---|
| Boys | .390 |
| Girls | 1.382 |

The values are not significant.

It does not seem likely therefore that our righthanded children differ significantly from our lefthanded as regards intelligence.

## Eye.

The eyedness of the children was then examined to establish if a righteyed boy or girl was significantly different from a lefteyed boy or girl. The mean 2nd I.Qs. and S.Ds. were calculated separately for all righteyed boys and girls and all lefteyed boys and girls.

Table 36 shows the means and S.Ds.

Table 36.

| Category | | Right Eye | | Left Eye |
|---|---|---|---|---|
| Boys | Mean | 84.40 | Mean | 82.59 |
| | S.D. | 1.29 | S.D. | 1.26 |
| Girls | Mean | 83.84 | Mean | 82.53 |
| | S.D. | 1.64 | S.D. | 2.02 |

The righteyed were then compared with the lefteyed by means of the t-test.

t-values for boys and girls are:-

| | | Righteyed with lefteyed. |
|---|---|---|
| t-values. | Boys | .983 |
| | Girls | .499 |

The values are not significant. It seems unlikely therefore that eyedness is exerting any major effect on intelligence.

## Crosslaterals.

The crosslateral groups of children, i.e. RHLE and LHRE were then combined in order to assess the significance with intelligence test result. The mean 2nd I.Q. and S.Ds. were found for these combined groups for boys and girls separately. Table 37 presents these figures.

Table 37.

Means and S.Ds. of crosslateral categories for 2nd I.Q.

Boys and Girls.

Crosslaterals.

| Category | | RHLE + LHRE | Category | | RHLE + LHRE |
|---|---|---|---|---|---|
| Boys | Mean | 83.40 | Girls | Mean | 83.52 |
| | S.D. | 1.17 | | S.D. | 2.10 |

These crosslaterals were then compared with a 'pure' group i.e. a group containing no crosslaterals and no ambi-cases: therefore pure dextrals, i.e. RHRE, plus pure sinistrals, i.e. LHLE. The means and S.Ds. of the 2nd Intelligence Quotient were calculated for boys and girls of this pure group. Table 38 presents these figures for boys and girls.

Table 38.

Pure Group.

| Category | | RHRE + LHLE | Category | | LHLE + LHLE |
|---|---|---|---|---|---|
| Boys | Mean | 84.13 | Girls | Mean | 81.31 |
| | S.D. | 1.54 | | S.D. | 1.13 |

The two groups, crosslateral and pure, were then compared with each other by means of the t-test.

t-values for boys and girls are

| | Cross with Pure |
|---|---|
| Boys | .385 |
| Girls | .979 |

These values are not significant.

It seems unlikely therefore that the influence of mixed hand or eye has any major effect on intelligence significantly different from coincidence of hand and eye.

Finally the two aspects of the crosslaterals were compared with each other to find if there was any specific difference between RHLE cases or LHRE cases.

The means and S.Ds. of the 2nd I.Q. were calculated for boys and girls separately.

Table 39 presents the data.

Table 39.

| | | RHLE | | | LHRE |
|---|---|---|---|---|---|
| Boys | Mean | 83.15 | Boys | Mean | 83.88 |
| | S.D. | 1.42 | | S.D. | 2.09 |
| Girls | Mean | 81.90 | Girls | Mean | 86.56 |
| | S.D. | 2.67 | | S.D. | 3.33 |

These categories were then compared and t-values for boys and girls are

| | | Righthanded lefteyed with Lefthanded righteyed |
|---|---|---|
| t-values | Boys | .292 |
| | Girls | 1.061 |

These values are not significant.

It does not appear important therefore to be RHLE in preference to LHRE as no significant difference emerges in relation to intelligence.

None of these values are significant for the respective groups. It seems unlikely then that handedness or eyedness

is exerting any major effect on intelligence with this Retarded Group of boys and girls.

## Laterality and Achievement.

In order to estimate the relationship between hand and eye and its effect on the achievement of the Retarded Group in their reading and spelling tests, an examination was again made with respect to the various categories of hand and eye.

The relationship of educational age to mental age is expressed in the Accomplishment Quotient and represents the performance of the children in relation to their capacity.

The distribution of the 2nd Accomplishment Quotient for the total Retarded Group was drawn for boys and girls separately. Fig. 19 presents the data.

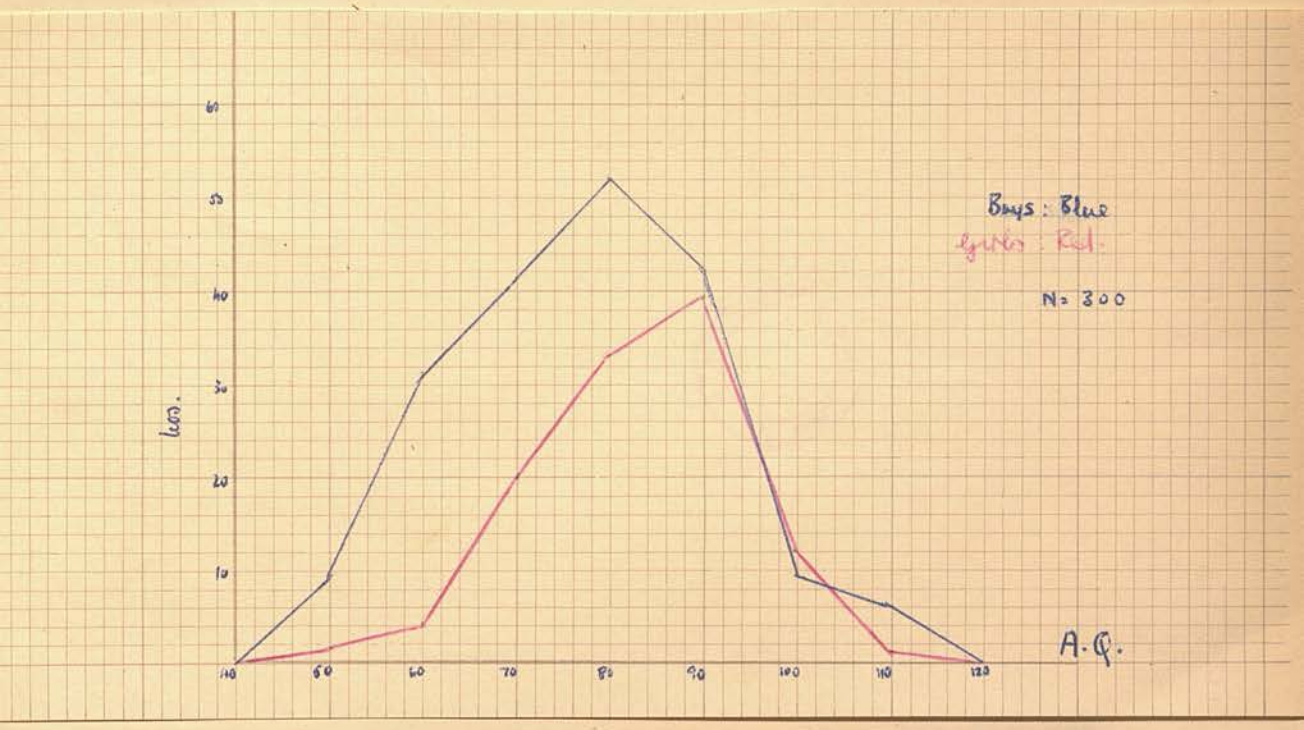



Fig. 19.

Distribution of 2nd A.Qs. for boys and girls separately. Retarded Group.

For boys alone the Mean 2nd A.Q. for
Retarded Group = 81.62
S.D. = .44

For girls alone the Mean 2nd A.Q. for
Retarded Group = 87.66
S.D. = .81

The total Retarded Group was then subdivided into categories of hand and eye. The mean 2nd A.Qs. and S.Ds. were then calculated for these subcategories.

Table 40 presents the Means and Standard Deviations of the Means for the 2nd Accomplishment Quotient for the respective categories of hand and eye, i.e. RHRE, RHLE, LHRE, LHLE, Ambi-R, Ambi-L, for boys and girls separately.

Table 40.

Means and S.Ds. of 2nd A.Q. for Categories of Hand and Eye.

| Category | RHRE | RHLE | LHRE | LHLE | Ambi-R | Ambi-L |
|---|---|---|---|---|---|---|
| Boys alone | | | | | | |
| Mean | 81.72 | 81.03 | 80.64 | 77.46 | 89.8 | 94.3 |
| S.D. | 1.60 | 1.97 | 1.88 | 2.93 | | |
| Girls alone | | | | | | |
| Mean | 88.33 | 84.13 | 87.56 | 95.30 | 80.0 | 95.0 |
| S.D. | 1.34 | 2.11 | 3.11 | 1.86 | | |

All boys Mean 2nd A.Q. = 81.62
S.D. = .44

All girls Mean 2nd A.Q. = 87.66
S.D. = .81

In all categories of Hand and Eye except for Ambi-R, the mean A.Q. of the girls is higher than for the boys, and in keeping with the higher total mean A.Q. for all the girls.

## Hand.

In order to test the effect of 'hand' alone on Achievement test result the means and S.Ds. of the means of the 2nd Accomplishment Quotient were found for all righthanded and lefthanded boys, irrespective of eye. Similar measures were calculated for all righthanded and lefthanded girls. Table 41 presents these measures.

Table 41.

Means and S.Ds. of right and lefthanded boys and girls.

| | | 2nd A.Q. | |
|---|---|---|---|
| Category | | Right hand | Left hand |
| Boys | Mean | 81.39 | 79.74 |
| | S.D. | 1.26 | 1.58 |
| Girls | Mean | 86.72 | 90.54 |
| | S.D. | 1.17 | 2.15 |

## Eye.

To establish the significance of the eye alone, the means and standard deviations for all righteyed boys and girls and lefteyed boys and girls, irrespective of hand - were calculated: boys and girls separately. Table 42 presents these measures.

Table 42.

Means and S.Ds. for right and left eyed boys and girls.

Retarded Group.

| Category | | Right eye | | Left eye |
|---|---|---|---|---|
| Boys | Mean | 81.77 | Mean | 81.43 |
| | S.D. | 1.19 | S.D. | 1.71 |
| Girls | Mean | 87.78 | Mean | 87.49 |
| | S.D. | 1.23 | S.D. | 1.74 |

Crosslaterals.

The mean 2nd Accomplishment Quotients and Standard Deviations of the means were found for the crosslaterals by combining the two groups i.e. RHLE and LHRE for boys and girls separately, in order to study the significance of crosslaterality on achievement result. Table 43 presents the data.

Table 43.

Crosslaterals (groups combined) for boys and girls.

| Category | | RHLE + LHRE | Category | | RHLE + LHRE |
|---|---|---|---|---|---|
| Boys | Mean | 80.90 | Girls | Mean | 85.33 |
| | S.D. | 1.45 | | S.D. | 1.75 |

Finally a 'pure' group was obtained by combining pure dextrals i.e. RHRE children with pure sinistrals, i.e. LHLE. These formed a group classified as 'pure' in that they contained no crosslateral or ambi cases. Table 44 presents the means and S.Ds. of the means for the 2nd A.Q. of this group.

Table 44.

'Pure' Group.

| Category | | RHRE + LHLE | Category | | RHRE + LHLE |
|---|---|---|---|---|---|
| Boys | Mean | 81.05 | Girls | Mean | 89.53 |
| | S.D. | 1.43 | | S.D. | 1.20 |

The crosslaterals were then considered separately and the means and S.Ds. of each category computed. Table 45 presents these results.

Table 45.

| Category | | RHLE | | LHRE |
|---|---|---|---|---|
| Boys | Mean | 81.03 | Mean | 80.64 |
| | S.D. | 1.97 | S.D. | 1.88 |
| Girls | Mean | 84.13 | Mean | 87.56 |
| | S.D. | 2.11 | S.D. | 3.11 |

The differences between the means of these various groups were compared for significance by the t-test.

The righthanded group was compared with the lefthanded for significance of 'hand' on achievement.

The righteyed group likewise was compared with the lefteyed group to test the significance of 'eye' on achievement.

The crosslaterals were then compared with the pure groups to establish which combination of hand and eye seemed to be exerting most effect.

Finally the two types of crosslaterals were compared with each other to test the respective significance, i.e.

RHLE with LHRE.

These comparisons were made in every case for boys and girls separately. Table 46 presents the t-values of the different comparisons.

Table 46.

t-values for 2nd A.Q.

| Comparison | RH/LH | RE/LE | Pure/Cross | RHLE/LHRE |
|---|---|---|---|---|
| Boys | .708 | .164 | .074 | .129 |
| Girls | 1.606 | .139 | 2.045[x] | .934 |

One only of these values is significant. The comparison of the pure with crosslateral group of girls. The value of 2.045 is significant at the .05 level. It would seem likely therefore that the 'pure' group, i.e. the righthanded, righteyed combined with the lefthanded, lefteyed or where coincidence of hand and eye is present, are achieving at a higher level than the crosslateral girls of mixed dominance. There is no significance among the groups of boys.

In general therefore the influence of hand and eye does not seem to be affecting accomplishment to any major extent except in the single group of pure with crosslateral girls in this total group of retarded children.

## Summary of Laterality Characteristics of Retarded Group.

The high percentage of mixed hand and eye cases is in keeping with previous investigations of groups with subnormal intelligence.

The mean intelligence level of the group as a whole enters the dull grading both for boys and girls.

The mean achievement of the group as a whole is in the dull category with girls showing achievement above innate capacity level.

Categories of hand and eye tested for significance on intelligence yield no significant results. Hand and eye thus do not appear to be exerting any major effect on the intelligence of this group.

Categories of hand and eye were examined for significance on achievement. With the exception of one category no significant effect was shown.

The pure dextral plus pure sinistral girls compared with the crosslateral girls, i.e. RHLE + LHRE show significant values at the .05 level. The 'pure' group appear to be working at a significantly higher level than do the crosslaterals.

The boys show no significant difference.

On the whole the categories of hand and eye do not appear to be exerting any major effect on either the intelligence or achievement of this Retarded group of boys and girls.

## References.

35. Gordon H. 1920 - Lefthandedness and mirror writing especially among defective children. Brain 1920 - 43, 313 - 368.

67. Mintz A. 1947 - Lateral preferences of a Group of Mentally Subnormal Boys. Journal Genet. Psychology. 1947 - 71, 75 - 84.

## Chapter 6.

## (C)

## Analysis of Laterality Characteristics of the Twin Group. in Relation to Intelligence and Achievement of the Group.

The Twin Group numbered 300 children, or 150 pairs, 144 boys and 156 girls. These twins were in family groups of 49 pairs of girl twins; 43 pairs of boy twins and 58 pairs of girl and boy twins.

The laterality characteristics of this group in relation to ingelligence and achievement will be studied first and in a further chapter the twins in family pairs will be analysed.

The 300 Twin boys and girls were examined on hand and eye tests and the numbers and percentages in each category noted as in Table 10, in Appendix B.

As previously noted the Twin Group present the highest percentage in the pure dextral group and the lowest combined percentage of crosslateral cases, there being more crosslateral boy twins than girl twins.

In considering the handedness of the above group, irrespective of eye, 28% of the total group are lefthanded. This is a higher percentage than was found for the Total Group of 770 children. Thus this subgroup of twins show the highest percentage for left handedness, irrespective of eye. Previous investigators have noted the high

percentage of lefthandedness among twins. Dahlberg 1926 (19) found 16.5% of uniovular twins to be lefthanded instead of an expected 5%. This is explained by a reversal of asymmetry in a proportion of uniovular twins where one twin is regarded as the mirror image of the other and is thus opposite handed. Newman, Freeman and Holzinger in 1937 have pointed out that lefthandedness in binovular twins although only about a quarter as common as in uniovular twins is nearly twice as frequent as in the general population. This has been explained as being due to the fact that possibly a proportion of the binovular twins are the survivors of triplet or quadruplet sets, some members of which were identical twins and the lefthander from one zygote has survived as the twin of the righthander from the other zygote. This view is supported by the observation that the coincidence of lefthandedness and twinning in the same fraternity is frequent. In 1939 Rife (84) showed that reversal is more likely to happen in uniovular and binovular twins if lefthandedness is in the family. It had been shown by Chamberlain in 1928 (12) that when both parents were righthanded, 2.1% of their offspring were lefthanded but when one or both parents were lefthanded the incidence of lefthandedness in the children rose to 17.34%. In 33 families where both parents were lefthanded, the incidence of lefthandedness was 46% in the children. Twinning may thus be considered as the hereditary factor and the isolated lefthanders are the lefthanded survivors of

pairs of uniovular twins.

Several investigators have observed that in many twin pairs one individual appears righthanded and the other lefthanded. This was found with the present group. Von Verschuer 1927 (106) found in contrast to Dahlberg - a greater percentage of lefthandedness among fraternal twins.

Wilson and Jones 1932 (112) found about 11% of lefthanded individuals among both types of twins as compared with 6½% among the single born. Newman combined the data of the studies of Dahlberg, Hirsch, Newman and Von Verschuer in order to form a more complete picture of the whole situation. According to his composite figures there were 24% clear cases of reversed handedness in 274 pairs of fraternal twins, handedness being determined by a report on the hand used in such activities as writing and throwing a ball. Later studies by Newman where he used motor skill in 'wrist tapping' and 'finger tapping' as a criterion of lateral dominance showed in 50 pairs of identical twins, 16% of clear reversed handedness and 10% of righthandedness in one twin of a pair and ambidexterity in the other. In 50 pairs of fraternal twins however, only 7% of clear mixed handedness was apparent and 4% of righthandedness in one twin and ambidexterity in the other. When data from the mother's reports and motor skill tests were combined, 26% of the identical twins and 8% of fraternal

twins gave a clear picture of reversed handedness. In an additional 8% of the identical twins and in an additional 3% of the fraternal twins, one twin was RH the other ambidextrous. These data would seem to indicate that reversed handedness occurs somewhat more frequently in pairs of identical twins than in twins in general. Training and a desire to make twins alike may account for smaller percentages. When twins are reared apart, the percentage of reversed handedness is increased. In 20 pairs reared apart, 11 pairs showed reversed handedness. More information on the question of handedness will be apparent in the study of the twins in family pairs. For the present the expectation of a higher incidence of lefthanders among twins when compared with non-twins appears justified as the percentage of lefthanders in the Normal Group was 27.05%, while the percentage in the Retarded Group was 23.99% (irrespective of eyedness in each case). The Normal Group is influenced by the numbers which are smaller.

In order to study the effects of these laterality findings on the intelligence and achievement of theTwin Group, the Mean 2nd Intelligence Quotient was calculated for Boy and Girl Twins separately.

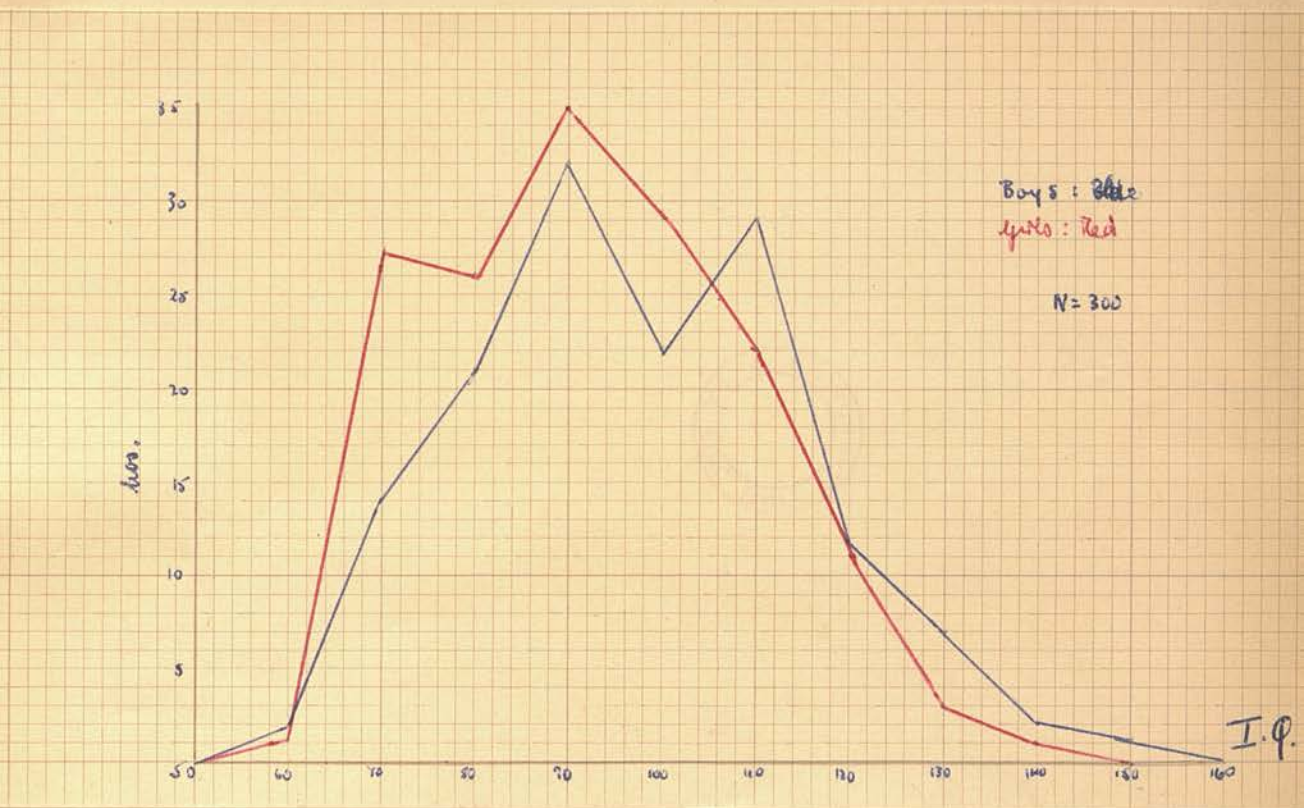
The Mean 2nd I.Q. for Twin boys alone = 101.49
S.D. = 1.52

The Mean 2nd I.Q. for Twin girls alone = 96.42
S.D. = 1.41

The boys among the twins in this group appear to be of higher intelligence than the girls.

In Fig. 20 is presented the 2nd Intelligence test distribution for boys and girls separately for the twin group.

Fig. 20.




The distributions are interesting in that they are bimodal for both girls and boys.

As with the other groups the total Twin Group was subdivided into categories of hand and eye. The means and standard deviations were then found for each category.

Table 47 shows the means and standard deviations of the 2nd I.Q. for the various categories of hand and eye, i.e. RHRE, RHLE, LHRE, LHLE, Ambi-R and Ambi-L for boys and girls separately.

Table 47.

2nd I.Q., Means and S.Ds.

| Category | | RHRE | RHLE | LHRE | LHLE | Ambi-R. | Ambi-L. |
|---|---|---|---|---|---|---|---|
| Boys | Mean | 104.95 | 99.89 | 97.86 | 99.50 | 109.0 | 65.0 |
| | S.D. | 2.31 | 2.56 | 3.16 | 6.49 | | |
| Girls | Mean | 94.64 | 99.20 | 98.17 | 96.89 | 92.3 | |
| | S.D. | 2.19 | 2.40 | 3.76 | 4.15 | | |

Twin Group - All Boys - Mean 2nd I.Q. = 101.49
S.D. = 1.52

Twin Group - All Girls - Mean 2nd I.Q. = 96.42
S.D. = 1.41

Hand.

In order to study the significance of right or left handedness on intelligence, the means and standard deviations were calculated for all righthanded boys and girls and all lefthanded boys and girls separately for the two groups. Table 48 presents the data.

Table 48.

Means and S.Ds. of 2nd I.Q. for right and lefthanded boys and girls.

| Category | | Righthanded | | Lefthanded |
|---|---|---|---|---|
| Boys | Mean | 103.08 | Mean | 98.40 |
| | S.D. | 1.75 | S.D. | 2.97 |
| Girls | Mean | 96.08 | Mean | 97.60 |
| | S.D. | 1.68 | S.D. | 3.56 |

The differences between the means of these categories were tested for significance by the t-test.

| | | Righthanded compared with lefthanded. |
|---|---|---|
| t-values | Boys | 1.411 |
| | Girls | .343 |

These values are not significant. It would seem therefore that 'hand' exerts no major effect on the intelligence of the twin group.

Eye.

To establish the significance of 'eye' alone with intelligence the means and S.Ds. were calculated separately for all righteyed boys and girls and also for all lefteyed boys and girls. Table 49 presents the data.

Table 49.

Means and S.Ds. of 2nd I.Q. for right and lefteyed boy and girl twins.

| Category | | Right eye | | Left eye |
|---|---|---|---|---|
| Boys | Mean | 102.84 | Mean | 99.12 |
| | S.D. | 1.88 | S.D. | 2.57 |
| Girls | Mean | 95.37 | Mean | 98.39 |
| | S.D. | 1.85 | S.D. | 2.11 |

Comparisons were then made of the means of the righteyed boys and girls with lefteyed boys and girls by t-test.

| | | Righteyed with lefteyed |
|---|---|---|
| t-values | Boys | 1.179 |
| | Girls | .882 |

The values are not significant. It would seem therefore that 'eyedness' of the twin group is exerting no major effect on intelligence.

The twins showing crosslateral tendencies were then combined in one category, i.e. righthanded lefteyed were combined with the lefthanded righteyed.

The means and standard deviations were calculated separately for boys and girls in this combined crosslaterality group. Table 50 presents the data for boys and girls separately.

Table 50.

Crosslaterals - Means and S.Ds. of 2nd I.Q.

| Category | | RHLE + LHRE | Category | | RHLE + LHRE |
|---|---|---|---|---|---|
| Boys | Mean | 99.02 | Girls | Mean | 98.79 |
| | S.D. | 1.98 | | S.D. | 2.06 |

Finally to compare with the crosslateral group, the pure dextrals i.e. RHRE were combined with the pure sinistrals, i.e. LHLE to form a 'pure' group, - a group containing no crosslateral or ambi cases. The means and S.Ds. of the 2nd Intelligence Quotients were calculated. Table 51 presents the data for boys and girls.

Table 51.

Pure Group - Means and S.Ds. of 2nd I.Q.

| Category | | RHRE + LHLE | Category | | RHRE + LHLE |
|---|---|---|---|---|---|
| Boys | Mean | 103.96 | Girls | Mean | 95.09 |
| | S.D. | 2.22 | | S.D. | 1.93 |

The crosslateral combined group was then compared with the pure group to establish significance.

| | | Cross with Pure |
|---|---|---|
| t-values | Boys | 1.633 |
| | Girls | 1.115 |

The values are not significant. The combinations of hand and eye do not appear therefore to be exerting a major effect on intelligence.

Finally the crosslateral groups, i.e. RHLE and LHRE were each compared. The means and standard deviations were computed. Table 52 presents the data.

Table 52.

| | RHLE | | | LHRE | |
|---|---|---|---|---|---|
| Boys | Mean | 99.89 | Boys | Mean | 97.86 |
| | S.D. | 2.56 | | S.D. | 3.16 |
| Girls | Mean | 99.20 | Girls | Mean | 98.17 |
| | S.D. | 2.40 | | S.D. | 3.76 |

t-values for the above categories are

| | RHLE with LHRE |
|---|---|
| Boys | .505 |
| Girls | .242 |

These values are not significant, hence the combinations of crosslaterals either way show no major effect on intelligence.

None of the previously found values are significant. Hence a conclusion must be drawn that hand and eye have little effect on the intelligence of the twin group.

## Laterality and Achievement.

The laterality of the twin group was examined to see whether combinations of hand and eye exerted significant effect on the achievement of the twins in reading and spelling tests.

The Accomplishment Quotient expresses the extent to which the twin group is working to capacity.

Fig. 21 presents the distribution of the 2nd Accomplishment Quotients for boys and girls separately.

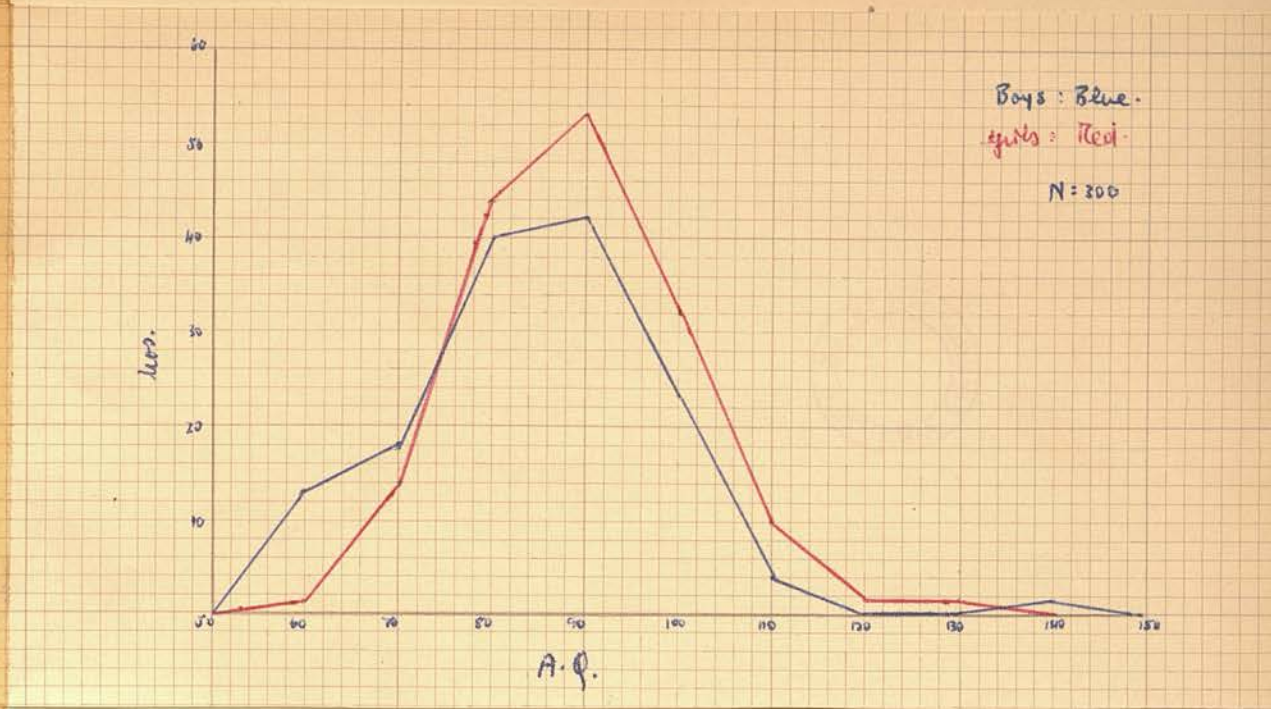



Fig. 21.

Twin Group.

For boys alone the Mean 2nd A.Q. for the Twin Group =

| | |
|---|---|
| Mean | 87.99 |
| S.D. | .62 |

For girls alone =

| | |
|---|---|
| Mean | 93.47 |
| S.D. | .61 |

The girl twins are thus working at a higher level than the boy twins in this group.

As with the other groups the Twin Group was then examined in its various categories of hand and eye. The means and standard deviations of each of these categories was then calculated.

Table 53 presents the means and standard deviations of the means for the 2nd Accomplishment Quotient for the respective categories of hand and eye, i.e. RHRE, RHLE, LHRE, LHLE, Ambi-R, Ambi-L, for boys and girls separately.

Table 53.

Means and S.Ds. of 2nd A.Q. for Categories of hand and eye.

| Category | | RHRE | RHLE | LHRE | LHLE | Ambi-R | Ambi-L |
|---|---|---|---|---|---|---|---|
| Boys | alone Mean | 84.40 | 89.76 | 92.75 | 88.43 | 82.0 | 116.0 |
| | S.D. | 1.46 | 2.69 | 2.18 | 3.59 | | |
| Girls | alone Mean | 93.22 | 92.29 | 93.17 | 96.32 | 98.0 | - |
| | S.D. | 1.40 | 1.72 | 2.26 | 2.34 | | |

All Boys Mean 2nd A.Q. = 87.99
S.D. = .62

All Girls Mean 2nd A.Q. = 93.47
S.D. = .61

## Hand.

In order to test the effect of 'hand' alone on achievement the means and standard deviations of the 2nd A.Q. were found for all right and lefthanded boys and girls separately - irrespective of eye. Table 54 presents the data.

Table 54.

Means and S.Ds. of right and lefthanded boys and girls.

| Category | | Right hand | | Left hand |
|---|---|---|---|---|
| Boys | Mean | 86.38 | Mean | 91.31 |
| | S.D. | 1.37 | S.D. | 1.88 |
| Girls | Mean | 92.93 | Mean | 94.60 |
| | S.D. | 1.10 | S.D. | 1.63 |

Eye.

To establish the significance of the effect of 'eyedness' on achievement the means and standard deviations of the right and lefteyed groups of boys and girls were calculated irrespective of 'hand'. Boys and girls were calculated separately. Table 55 presents the data.

Table 55.

Means and S.Ds. for right and lefteyed boys and girls.

Twin Group.

| Category | | Right Eye | | Left Eye |
|---|---|---|---|---|
| Boys | Mean | 86.91 | Mean | 89.90 |
| | S.D. | 1.26 | S.D. | 2.19 |
| Girls | Mean | 93.35 | Mean | 93.70 |
| | S.D. | 1.18 | S.D. | 1.40 |

Crosslaterals.

The mean 2nd A.Q. and S.Ds. of the means were found

for the crosslateral groups, by combining the two groups, i.e. RHLE with LHRE for boys and girls separately. This rendered possible a study of the effect of crosslaterality on achievement. Table 56 presents the data.

Table 56.

Crosslaterals (Groups combined) Boys and Girls.

2nd A.Q.

| Category | | RHLE + LHRE | | |
|---|---|---|---|---|
| Boys | Mean | 91.05 | Girls Mean | 92.64 |
| | S.D. | 1.79 | S.D. | 1.36 |

Finally a 'pure' group was obtained by combining pure dextrals, i.e. RHRE children with pure sinistrals, i.e. LHLE. These formed a group classified as 'pure' as no crosslaterals or ambi-cases were included. Table 57 presents the means and S.Ds. for the 2nd A.Q. of this group.

Table 57.

Pure Group.

| Category | | RHRE + LHLE | Category | RHRE + LHLE |
|---|---|---|---|---|
| Boys | Mean | 85.13 | Girls Mean | 93.84 |
| | S.D. | 1.36 | S.D. | 1.22 |

The differences between the means of the various groups were compared for significance by the t-test.

The righthanded group was compared with the lefthanded to assess the significance of handedness on

achievement.

The righteyed group was compared with the lefteyed to establish the significance of eyedness on achievement.

The crosslaterals were then compared with the pure group to establish which combination of hand and eye, i.e. pure dominance or mixed dominance - seemed to be influencing achievement most.

Finally the two categories of crosslaterality were compared with each other to test the significance of the respective groups, i.e. RHLE with LHRE.

These comparisons were made in every case for boys and girls separately. Table 58 presents the t-values for the different comparisons.

Table 58.

Twin Group.

t-values. 2nd A.Q.

| Comparison | RH/LH | RE/LE | Pure/Cross | RHLE/LHRE |
|---|---|---|---|---|
| Boys | 2.017$^{x}$ | 1.274 | 2.670$^{xx}$ | .824 |
| Girls | .814 | .184 | .639 | .317 |

Two of these values are significant. The comparison of the RH/LH for boys yields a t-value of 2.017 which is significant at the .05 level. It would seem therefore that the lefthand is exerting a more significant influence than the right on the achievement of this group of boy twins such that the lefthanders are working at a higher level.

The second significant difference lies in the Pure/Cross

Boys' comparison where the t-value of 2.670 is significant at the .01 level. The crosslateral boys of this group appear to be working at a higher level than the pure dextrals or sinistrals. These differences would appear to amplify the conclusion that the effect of 'handedness' is negligible if non-existent on intelligence and achievement. If one clings to the assumption that a lefthander will fare worse educationally because of his sinistrality, this assumption is not found with these groups. Indeed the opposite is established with the boy twins where the lefthanders are achieving at a higher level than the righthanders. Particularly is this apparent with the crosslateral categories when compared with the 'Pure'. Thus those boy twins lacking coincidence of hand and eye are working better than the boy twins who show agreement.

As the significances throughout the different groups of Normal Retarded and Twins do not conform to any particular order it seems unlikely therefore that handedness or eyedness has much effect on accomplishment or intelligence.

It is also impossible to state which has the greater effect, hand or eye.

## Summary of Laterality Characteristics of Twin Group.

The highest percentage of Pure Dextrals found with Twin Group.

The lowest combined crosslateral percentage found with this Twin Group. More boys than girls show crosslaterality here.

A high percentage of left-handedness irrespective of eye present with this group. This is in agreement with previous investigators. The Boys appear to be of higher intelligence than the girls.

The level of the Twin Group as a whole is at average grading.

Categories of Hand and Eye tested for significance with intelligence yield no significant values for boys and girls.

The accomplishment of the Group is below capacity, with the girls' achievement at a higher level than the boys.

The respective categories of hand and eye tested for significance with achievement. Two values only are significant. Lefthanded boy twins working at a significantly higher level than righthanded boy twins. Crosslateral boy twins, when compared with pure dextral and sinistral boy twins, appear to be working at a higher level. No significance was found for the girl twins.

## References.


19. Dahlberg S. - Twin births and twins from an hereditary point of view. Stockholm 1926.

84. Rife D.C. - Genetic Studies of Monozygotic Twins. III Mirror Imaging. J. Hered. 1933 - 24, 443 - 446.

12. Chamberlain H.D. - 1928. The Inheritance of Lefthandedness. J. Hered. 1928 - 19, 557 - 559.

71. Newman, H.H., Freeman F.H., Holzinger K.J. - Twins. A Study of heredity and environment. Chicago. Chicago Univ. Press, 1937.

54. Lauterbach E.C. - Studies in twin resmblance. Genetics. 1925 - 10, 525 - 568.

106. Von Verschuer.- 1927. Der Vererbungsbiologische Zwillingsforschung, Ergeb. Innern Med. U Kinderheit, 1927. 31.

112. Wilson P.T. and Jones H.E. - Lefthandedness in twins. Genetics 1932 - 17, 560 - 571.

69. Newman H.H. - Studies of Human Twins II. Asymmetry, reversal or mirror-imaging in Identical Twins. Biol. Bull. 1928 - 55, 298 - 315.

## Chapter 7

### Laterality Comparison of Groups.

In the previous chapters the mean intelligence quotients and mean accomplishment quotients were calculated for the categories of hand and eye within each group.

The groups as a whole were then compared. Firstly the Normal Group was compared with the Twin Group to ascertain any significant differences in the respective intelligence test results and then similarly compared on accomplishment.

The Normal Group was then compared with the Retarded Group for significant differences on intelligence test result and accomplishment.

The statistics have been marked thus -

x significant at .05 level.

xx significant at .01 level.

xxx significant at .001 level.

In each case the probability is less than .05, .01, .001 that the observed value could be obtained on the null hypothesis.

(A)

## Normal with Twins.

Table 59 presents the t-values of the means of the Normal Group when compared with the means of the Twin Group for boys and girls separately on I.Q. and A.Q.

### Table 59.

### Normal v Twins.

| Boys | R.E. | L.E. | Cross | Pure | R.H. | L.H. |
|---|---|---|---|---|---|---|
| I.Q. | 1.341 | .798 | 2.451* | .319 | .804 | .983 |
| A.Q. | .636 | 1.176 | .910 | 1.675 | 1.187 | .918 |
| Girls | | | | | | |
| I.Q. | 2.096* | .479 | .418 | 1.956 | 1.439 | 1.191 |
| A.Q. | .257 | 1.712 | .154 | 1.007 | 1.661 | .903 |

In considering the above values, two only are significant. The value obtained for the crosslateral boys group is significant at the .05 level. Thus the Normal boys in this category show higher intelligence than the Twin boys of crosslateral category. The mean I.Q. of the Normal boys is 106.51, S.D. 2.30, while that of the Twin boys is 99.02, S.D. 1.98. There is thus a real difference not due to chance.

The second significant value lies in the category of right eyed girls which shows significance at the .05

level. This difference is in favour of the Normal girls, showing higher intelligence than the Twin girls in righteyed category. The mean I.Q. of the Normal girls is 102.06, S.D. 2.34 while the mean I.Q. of the Twin girls is 95.37, S.D. 1.85.

No other value is significant. The Laterality of both the Normal and Twin Groups is thus not affecting their achievement and the two groups appear to be working at similar levels.

The two groups as a whole show little significant difference either in intelligence or achievement.

(B)

Normal with Retarded.

The Normal Group was then compared in its varying categories of hand and eye, with the Retarded Group to assess significant differences in intelligence and achievement.

Table 60 presents the t-values of the means of the Normal Group, compared with the means of the Retarded Group for boys and girls separately on I.Q. and A.Q. The significant values are marked as before.

Table 60.

| Boys | R.E. | L.E. |
|---|---|---|
| I.Q. | 9.315$^{xxx}$ | 7.387$^{xxx}$ |
| A.Q. | 3.325$^{xxx}$ | 3.052$^{xx}$ |
| **Boys** | **Cross** | **Pure** |
| I.Q. | 9.947$^{xxx}$ | 6.488$^{xxx}$ |
| A.Q. | 3.379$^{xxx}$ | 3.470$^{xxx}$ |
| **Boys** | **R.H.** | **L.H.** |
| I.Q. | 10.136$^{xxx}$ | 5.310$^{xxx}$ |
| A.Q. | 3.692$^{xxx}$ | 3.496$^{xxx}$ |

| Girls | R.E. | L.E. |
|---|---|---|
| I.Q. | 6.550$^{xxx}$ | 4.244$^{xxx}$ |
| A.Q. | 2.643$^{xx}$ | 3.583$^{xxx}$ |
| **Girls** | **Cross** | **Pure** |
| I.Q. | 4.949$^{xxx}$ | 8.108$^{xxx}$ |
| A.Q. | 2.533$^{x}$ | 3.221$^{xx}$ |
| **Girls** | **R.H.** | **L.H.** |
| I.Q. | 8.212$^{xxx}$ | 4.303$^{xxx}$ |
| A.Q. | 4.883$^{xx}$ | .234 |

Each of the values with reference to intelligence level, is highly significant - (.001 level) giving one chance in 1000 that the differences are chance ones. We can confidently conclude therefore that the Normal Group in all its categories is of higher intelligence than the Retarded Group. An interesting fact in this comparison is that the significant figures for the girls

are less than for the boys, hence it would appear that there is a greater difference in I.Q. between Normal and Retarded boys than between the Normal and Retarded girls. If one considers the respective mean I.Qs. for these two groups found in the initial retardation survey, it was apparent that the Normal Group approximated to the average in intelligence, while the Retarded Group was found to be one of dull grading in intelligence. These characteristics appear to have been maintained within the smaller laterality groups comprising the 770 children examined in detail.

In comparing the achievement of the Normal and Retarded Groups, it is interesting that again all the values are significant in varying degree exept for the lefthanded girls. This value is not significant. Thus it would seem that the achievement of the Normal and Retarded lefthanded girls is equal. The mean A.Q. for the lefthanded Retarded Group girls is 90.54, S.D. 2.15. The mean A.Q. for the lefthanded Normal Group girls is 89.79, S.D. 2.31. If one considers the respective mean I.Qs. of the two categories then the Normal lefthanded girls are achieving at a lower level than the Retarded lefthanded girls.

In comparing the groups as a whole on Achievement it would appear established that there are real differences between the Normals and Retardeds. As with intelligence the significance values for the girls are

less than for the boys, hence there are greater differences in achievement between Normal and Retarded boys than between the girls.

(C)

Total Group Comparison.

The Total Laterality Group, N: 770, was then considered alone. Categories of Hand and Eye were considered and examined to find if any significant differences emerged with I.Q. or A.Q. The handedness of the Total Group was considered in a comparison of righthanded children with lefthanded. Secondly, the eyedness of the Total Group was considered, and all righteyed children were compared with all lefteyed. The categories of Pure Dextrals, i.e. RHRE, were combined with the total Pure Sinistrals, i.e. LHLE, to form a 'Pure' Group. These children were then compared with the categories of crosslateral combined, i.e. RHLE plus LHRE. Finally, the crosslateral groups were compared to ascertain if any significance emerged with intelligence or achievement.

Table 61 presents the t-values for differences in comparison of Laterality with intelligence. The significant values are marked as before.

Table 61.

Total Laterality Group.

t-test : 2nd I.Q.

| | RH v LH | RE v LE | Cross v Pure | RHLE v LHRE |
|---|---|---|---|---|
| Boys | .796 | 2.101$^{x}$ | 1.376 | 0.659 |
| Girls | 1.210 | 0.746 | 0.601 | 1.478 |
| Boys + Girls | 0.160 | 2.047$^{x}$ | 0.588 | 1.446 |

The two significant values occur in the 'eyedness' category. They indicate that the righteyed boys are slightly superior in intelligence to the lefteyed boys. Likewise all the righteyed children in the group tend to be superior in intelligence to the lefteyed children.

The Achievement of the Total Laterality Group was then considered in the same way as for intelligence.

Table 62 presents the data.

Table 62.

t-test : 2nd A.Q.

| | RH v LH | RE v LE | Cross v Pure | RHLE v LHRE |
|---|---|---|---|---|
| Boys | 0.971 | 0.664 | 1.156 | 0.559 |
| Girls | 0.493 | 0.550 | 2.344$^{x}$ | 0.371 |
| Boys + Girls | 0.926 | 0.366 | 1.130 | 0.325 |

One value only is significant and occurs in the girls comparison. The comparison of crosslateral girls with pure dextrals and sinistrals combined is significant at the .05 level. It indicates that the 'pure' group of girls is working at a slightly higher level than the

'crosslateral' girls when the educational tests are considered.

No other value shows significance.

While the main trend of the Total Laterality Group shows that hand and eye have little effect on intelligence or achievement, the significant values which emerge suggest that the righteyed children have a greater advantage than the lefteyed, showing higher intelligence.

The trend in achievement suggests with girls that those who show consistent laterality of hand and eye are performing at a higher level than those girls who show mixed hand and eye or crosslaterality.

(D)

Sex Difference.

The Total Laterality Group and the three subgroups of Normal, Twins and Retarded have each been investigated with reference to the significance of laterality on Intelligence and Achievement. This was examined for boys and girls separately. It was then considered desirable to find out if any significant sex difference was present in the laterality of boys and girls in the groups considered separately. Accordingly the differences in the Normal, Twin and Retarded Groups were examined by means of the $X^2$ test. Each $X^2$ has 5 degrees of freedom.

Table 63 presents the data.

Table 63.

| | | |
|---|---|---|
| Normal Group | Boys v Girls | $X^2$ : 6.895 |
| Twins Group | Boys v Girls | $X^2$ : 4.046 |
| Retarded Group | Boys v Girls | $X^2$ : 2.716 |

None of these values is significant.

Table 63a presents the figures on which the results of Table 63 are based.

Table 63 a.

| | | RH | | LH | | Ambi | | |
|---|---|---|---|---|---|---|---|---|
| | | RE | LE | RE | LE | RE | LE | |
| Normal | Boys | 36 | 29 | 16 | 11 | 1 | 2 | 95 |
| | Girls | 37 | 16 | 14 | 5 | 3 | - | 75 |
| | | 73 | 45 | 30 | 16 | 4 | 2 | 170 |
| Twins | Boys | 63 | 37 | 28 | 14 | 1 | 1 | 144 |
| | Girls | 76 | 35 | 23 | 19 | 3 | - | 156 |
| | | 139 | 72 | 51 | 33 | 4 | 1 | 300 |
| Retarded | Boys | 69 | 64 | 33 | 13 | 5 | 6 | 190 |
| | Girls | 48 | 30 | 16 | 10 | 3 | 3 | 110 |
| | | 117 | 94 | 49 | 23 | 8 | 9 | 300 |

Thus a conclusion must be drawn that in the three subgroups of Normal Twin and Retarded children, no significant sex difference is apparent in laterality. The boys in each group do not differ significantly from the girls in each group by reason of their laterality only. Boys and girls in the groups may be thus equally affected or equally unaffected by the combination of their hand and eyedness.

## Summary of Comparison of Groups.

The Normal and Twin Groups when compared re Laterality and Achievement show no significant differences.

A similar finding was present re Intelligence with the exception of the Crosslateral boys and Righteyed girls. In both categories the members of the Normal Group show higher intelligence than the corresponding members in the Twin Group.

The Normal Group was found to be significantly superior to the Retarded Group in intelligence.

The Normal Group was found to be significantly superior to the Retarded Group in Achievement with the exception of the Lefthanded girls. In this category the girls of both groups are working at similar levels.

In the Total Group comparison of Laterality and Intelligence the significance values suggest that righteyed children in the group show superior intelligence to lefteyed.

When the Achievement of the Total Group is considered one significant value emerges which suggests that girls showing co-ordination of hand and eye are working at a higher level than girls of mixed hand and eye.

No sex difference was found in Laterality in any of the subgroups.

## Chapter 8.

## Association of Intelligence with Age.

An attempt was made to find any association between the ages of the children and their ratings on the Intelligence test. To find out if perchance the older children tended to show higher test levels than the younger, due perhaps to more familiarity with test material and testing procedures, or whether the intelligence level appreciably altered in any way.

The correlation coefficients were calculated for the respective categories of hand and eye for the boys and girls in each of the groups, Normal, Twins and Retarded. This was also done for the total boys alone, the total girls alone and for all the children combined. Any close association would then be thrown up with reference to any particular group of hand and eye category.

(A)

The Normal Group correlations follow.

The significant values are marked as before at the .05, .01 and .001 levels. As there were very few cases in the ambi-R and ambi-L categories, these correlations were omitted.

Table 64 presents the data.

Table 64.

Normal Group correlations of age with 2nd I.Q.

| Category | Boys | Girls | Boys + Girls |
|---|---|---|---|
| RHRE | -.011 | -.179 | -.075 |
| RHLE | .120 | -.052 | .055 |
| LHRE | -.435 | -.083 | -.193 |
| LHLE | -.299 | -.657 | -.339 |
| Total | -.112 | -.186 | -.124 |

None of these ratios are significant. Age therefore does not appear to be affecting the intelligence test result of the Normal Group when viewed as a whole and when viewed in each of its hand and eye categories.

(B)

Twin Group.

The Twin Group was then analysed in the same manner as for the Normals. Correlation coefficients were calculated and the data presented in Table 65.

Table 65.

Twin Group Correlations of age with 2nd I.Q.

| Category | Boys | Girls | Boys + Girls. |
|---|---|---|---|
| RHRE | .193 | -.161 | -.021 |
| RHLE | .038 | .283 | .157 |
| LHRE | -.250 | .184 | -.062 |
| LHLE | -.034 | -.254 | -.123 |
| Total | .029 | -.042 | -.011 |

When the Twins are viewed as a whole and when each category of hand and eye is considered none of the correlation ratios are significant. Hence one can conclude that age level is not affecting the intelligence level of the Twin Group.

(c)

Retarded Group.

The Retarded Group were then considered in the same way. Table 66 presents the data.

Table 66.

Retarded Group Correlations of age with 2nd I.Q.

| Category | Boys | Girls | Boys + Girls. |
|---|---|---|---|
| RHRE | $-.337^{xx}$ | -.094 | $-.279^{xx}$ |
| RHLE | -.093 | .320 | .072 |
| LHRE | -.280 | .135 | -.132 |
| LHLE | .296 | -.305 | .117 |
| Total | $-.235^{x}$ | $.211^{x}$ | -.075 |

In the pure dextral categories the correlations for the boys alone and for boys + girls show ratios significant at the .01 level. This would suggest that for these groups the older boys and older boys + girls are showing a poor intelligence test result as the association is negative.

The Total boys and the Total girls for this

Retarded Group show significant ratios at the .05 level. The boys show a negative result while that for the girls is positive though not high. The older boys are thus tending to poorer intelligence test result. The older girls are tending to show a positive relationship and therefore higher intelligence test result.

No other values show significance.

(D)

Total Laterality Group.

Finally the Total Laterality Group were investigated in a similar fashion. The three subgroups were combined and their categories of hand and eye studied in the association of age with intelligence test result. Table 67 presents the data.

Table 67.

Total Laterality Group Correlations of Age with 2nd I.Q.

(i.e. Normal + Retarded + Twin)

| Category | Total Boys | Total Girls | Total Boys + Total Girls |
|---|---|---|---|
| RHRE | .165$^{x}$ | .018 | .091 |
| RHLE | .154 | .397$^{xxx}$ | .248$^{xx}$ |
| LHRE | -.023 | .165 | .056 |
| LHLE | .158 | -.110 | .051 |
| Total | .115 | .129 | .120 |

The total boys as a group in the respective categories of hand and eye, show no significant

correlation ratios of intelligence test level with age (except for the RHRE group where r = .165 significant at the .05 level). Hence age does not appear to be operating with the boys as a factor influencing their test result in intelligence.

The girls show one significant ratio. The crosslateral girls, RHLE show a value of .397 which is significant at the .001 level. The correlation is not high but seems to indicate a definite association between the age of this category of girls and their I.Q. The older the girls, the better result they appear to show. These girls may be more used to testing, more 'test sophisticated', or they may be more stable and less anxious as a group showing more maturity with age and therefore able to reach a higher level.

The Total boys plus girls show only one significant correlation ratio. The crosslateral category, RHLE for boys plus girls shows a value, r = .248, which is significant at the .01 level. This crosslateral group therefore, like the girls, shows a definite and positive association between intelligence test level and age.

The correlations of intelligence with age viewed as a whole over the hand eye categories of the three groups of Normal, Twin and Retarded with the Total boys, girls and boys plus girls show negative and non-significant relationship.

The significant ratios obtained are, for the most

part, low, revealing association but not great. One can conclude therefore that age is not affecting the intelligence level of the groups. These correlations are remarkable for the many negative ones present and seem to be randomly enough distributed to support the idea that the I.Q. is approximately constant.

The correlations over 'all' children and groups of boys and girls are however positive.

## Chapter 9.

## Association of Accomplishment with Age.

As with intelligence a similar investigation was made with reference to the achievement of the groups. Correlation coefficients were calculated to assess any relationship existing between achievement and age - to find if a child as it grew older tended to have a lower A.Q. or vice versa. This was investigated for the three groups, Normal, Twin and Retarded and for boys and girls separately. The Total group was then considered in the same way.

(A)

Table 68 presents the correlations for 2nd Accomplishment Quotients with the age of the children separately for boys and girls and for each category of hand and eye. Significant ratios are marked.

Table 68.

Normal Group Correlations.

Age with 2nd A.Q.

| Category | Boys | Girls | Boys + Girls |
|---|---|---|---|
| RHRE | -.093 | -.020 | -.089 |
| RHLE | .083 | .010 | .082 |
| LHRE | -.250 | -.276 | -.214 |
| LHLE | -.213 | -.661 | -.286 |
| Total | -.041 | .020 | -.040 |

None of these correlation ratios are significant. One can thus conclude that the age of the Normal Group children is having no effect on their achievement.

(B)

Twin Group.

The Twin group was then considered in the same way. Table 69 presents the data.

Table 69.

Twin Group Correlations.

Age with Achievement.

| Category | Boys | Girls | Boys + Girls |
|---|---|---|---|
| RHRE | -.031 | .754$^{xxx}$ | .411$^{xxx}$ |
| RHLE | -.280 | .156 | -.099 |
| LHRE | .130 | -.238 | -.011 |
| LHLE | -.057 | -.185 | -.204 |
| Total | -.077 | .396$^{xxx}$ | .151 |

In the hand eye categories two values are significant at the .001 level. The pure dextral girl twins and the pure dextral boy + girl twins show high association between their age and achievement. Thus the older twins of these categories appear to be doing good work.

Likewise the ratio for the Total girl twins shows a positive and significant ratio at .001 level. The girl twins as a whole thus show a relationship with

their age and work such that the older girls are achieving at a higher level. The other categories of twins do not show a significant relationship and would appear to be unaffected by age in achievement.

(c)

The Retarded Group was then considered in its relationship of age to achievement. Table 70 presents the data.

Table 70.

Retarded Group Correlations.

Age with 2nd A.Q.

| Category | Boys | Girls | Boys + Girls |
|---|---|---|---|
| RHRE | -.0015 | .0030 | .014 |
| RHLE | -.024 | -.064 | -.044 |
| LHRE | -.114 | -.095 | -.091 |
| LHLE | .573[x] | .290 | .355 |
| Total | .005 | -.051 | -.010 |

The sole significant value is the correlation ratio for LHLE boys, r = .573. This is significant at the .05 level. With this category the older boys appear to be achieving at a higher level. The girls and boys + girls with other categories of the boys appear to be unaffected in work by age.

(D)

The Total Laterality Group was then considered with reference to its achievement. The categories of all the boys, all the girls and all children were considered and correlations calculated. Table 71 presents these ratios.

Table 71.

Total Group Correlations. (Normal + Twin + Retarded)

Age with Achievement.

| Category | Boys | Girls | Boys + Girls |
|---|---|---|---|
| RHRE | .054 | .474$^{xxx}$ | .251$^{xxx}$ |
| RHLE | .012 | .181 | .060 |
| LHRE | .128 | -.058 | .067 |
| LHLE | .274 | .074 | .053 |
| Total | .065 | .148 | .262$^{x}$ |

The Total boys show no significant correlation ratios. One value in the Total girls is significant. That for the RHRE girls r = .474, is significant at the .001 level. The association with this category of girls is not high but suggests a positive relationship between achievement and age such that the older girls here tend to show a high level of achievement.

With the Total boys plus girls group again the dextral category i.e. RHRE, show a value r = .251, which is significant at the .001 level. Thus the older children in this category tend to higher achievement although the ratio is not high.

Likewise for all the children in the group a small but positive association is present between achievement and age. Thus the older children are tending to show a higher achievement result. As the reading and spelling tests were of word accuracy it is possible that with age these were rather easy for the older members who were becoming familiar with the content of the tests and undoubtedly were accustomed on retest to the testing situation.

Taken as a whole however, over the hand eye categories in the subgroups, the association of age and achievement is mainly negative and not significant. The positive correlations are, for the most part, low. Thus one can conclude that the relationship which exists between age and achievement is not great. The older and younger children, over all the combinations of hand and eye, are doing probably equally well or equally badly in their work.

## Summary of Findings.

### Association of Age with Intelligence and Achievement.

Significant values emerged in association of age with intelligence only in the Retarded Group.

No significant association was found in either the Normal or Twin Groups.

In the Total Group significant association of age with intelligence was found in one category only.

Age is thus not significantly affecting the intelligence test results of the groups.

In estimating the association of age on achievement no significant values were found in the Normal Group.

In the Twin Group the Total girl twins and the dextral category of children revealed positive association between age and achievement.

With the Retarded Group the category of pure sinistral boys alone showed significance.

In the Total group the correlation for all children showed a small positive and significant relationship but taken as a whole over the hand eye categories in the subgroups, age does not appear to be affecting achievement significantly.

## Chapter 10.

## Shift Handed Group.

In comparing the Performance Test results with the results from the Van Riper Test, it was noted that several children showed right hand predominance on the performance tests on composite score, whereas on the Van Riper Test they were classified as lefthanded owing to the fact that mirroring occurred with the right hand. These children were regarded as a shifthanded group. If the Van Riper Board measures and uncovers innate handedness then these shifthanded children should be lefthanded, but as a result of training or enforced changeover, they may have become righthanders.

This group which numbered 199 children or 25.84% of the Total Laterality Group was studied separately to estimate the effect on achievement in school work, of shift of hand.

Boys and girls were considered separately and the mean I.Q. levels and standard deviations of the two groups were computed separately.

The mean Intelligence Quotient of the Shifthanded Group -

| | | |
|---|---|---|
| Girls | Mean | = 92.43 |
| | S.D. | = 17.1 |
| Boys | Mean | = 92.62 |
| | S.D. | = 18.7 |

The boys and girls in this group were thus of

similar intelligence at a low average grading.

Figure 22 presents the distribution of intelligence for boys and girls separately.

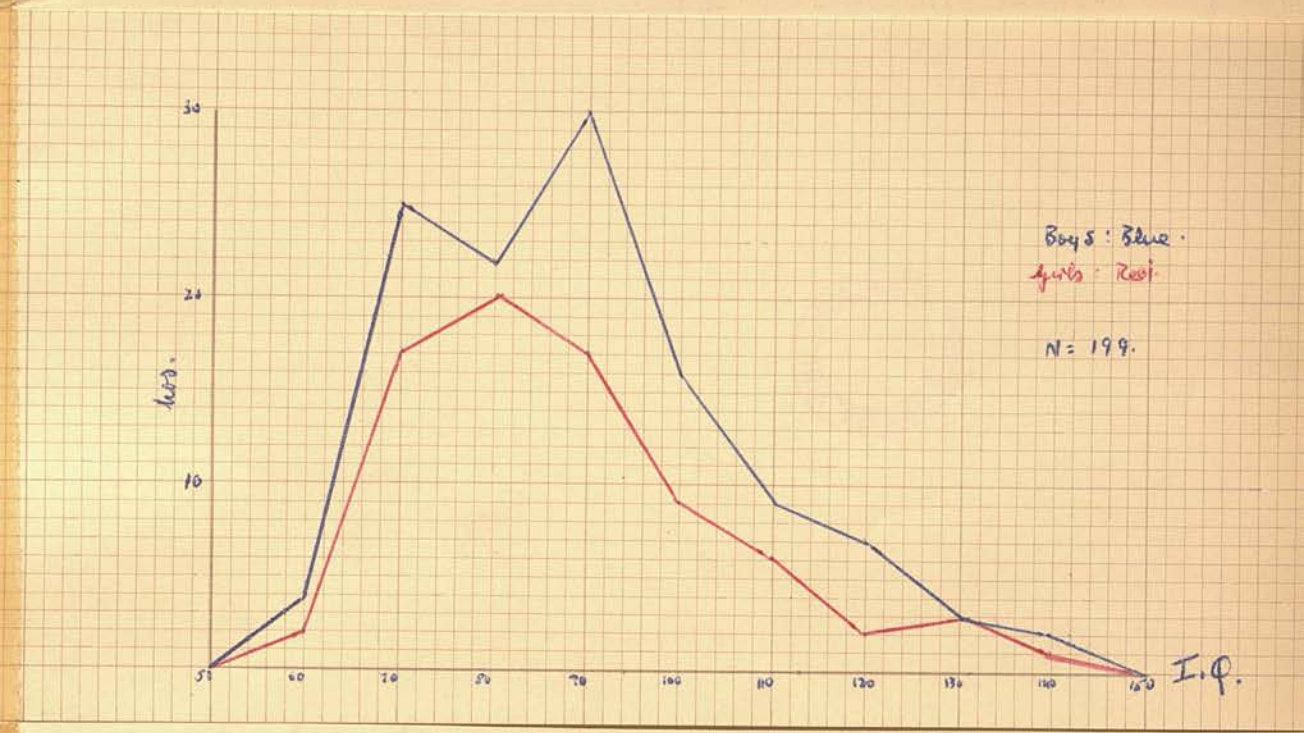



Fig. 22.

Distribution I.Qs. Boys - Girls.

The Achievement Quotients for Boys and Girls were then estimated for this group of Shifthanded children. The mean A.Qs. and Standard Deviations were computed.

| | | | |
|---|---|---|---|
| Boys | Mean A.Q. | = | 85.72 |
| | S.D. | = | 13.2 |
| Girls | Mean A.Q. | = | 92.3 |
| | S.D. | = | 11.3 |

By comparison with intelligence level the girls appear to be doing better than the boys as the latter are not

working to capacity. The girls are at capacity in achievement.

Figure 23 presents the accomplishment quotients for the boys and girls separately for this Shifthanded Group.

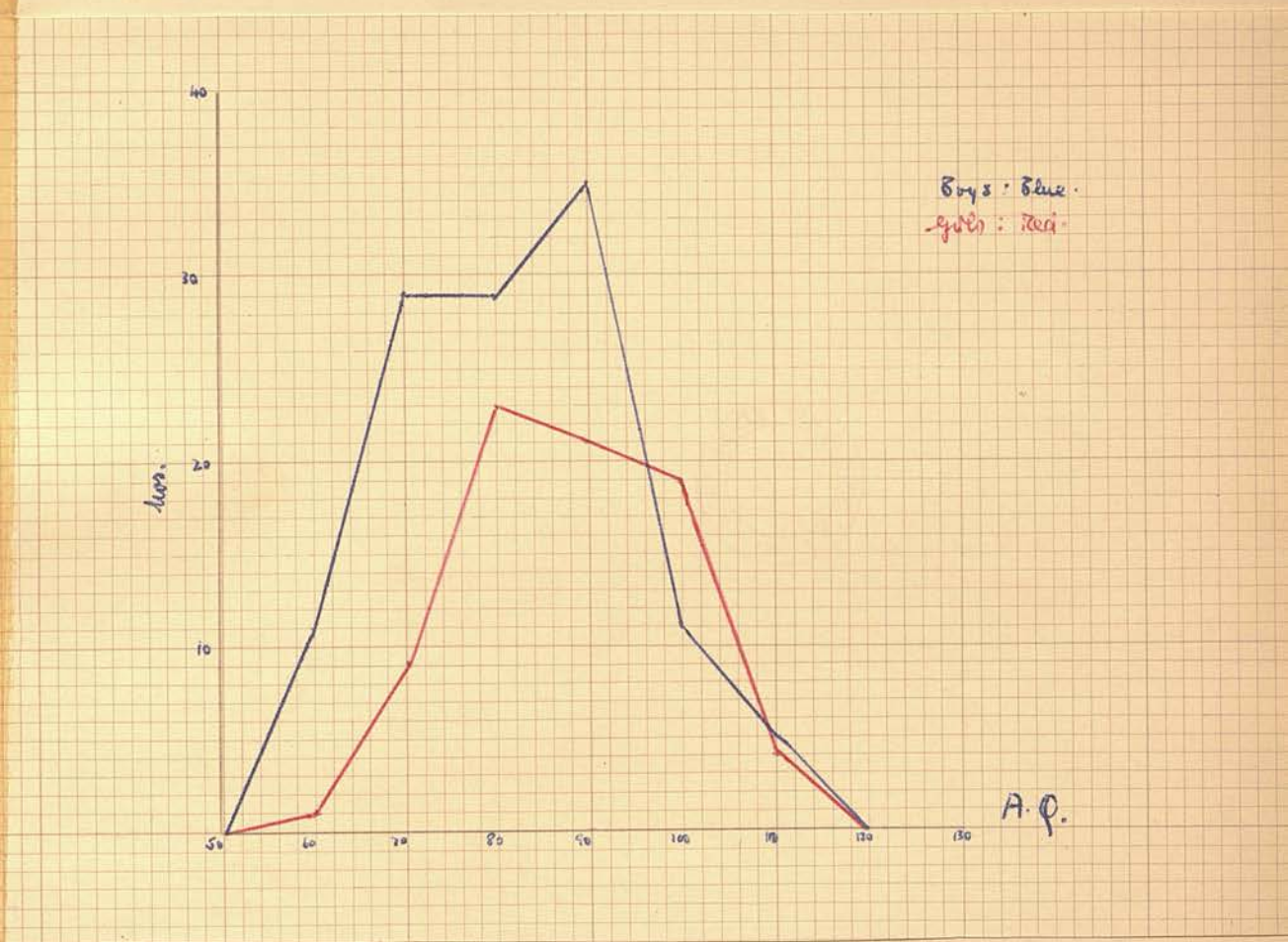



Fig. 23.

Distribution A.Qs. Boys and Girls.

In considering the subgroups of Normal, Twins and Retarded the percentage of each group who entered the 'Shifthanded' category was calculated. Of the complete Normal Group of 170 children, 19% showed inconsistency

of hand on the Performance and Van Riper. Considering boys and girls separately, 26% of the boys group and 11% of the girls group showed this characteristic. Thus twice the number of boys to girls were involved.

Among the total Twin Group of 300 children, it was found that 24% showed a 'Shifthanded' tendency. Of these 25% of the boys group and 24% of the girls group were involved. The sexes in the twin group were thus more evenly numbered in that as many boys as girls showed inconsistency.

In the total Retarded Group of 300 children it was found that31% of the group showed 'shifthandedness'. Among these 32% of the boys group and 29% of the girls group showed this characteristic.

The total amount of inconsistency on the two tests lies therefore with this Retarded or dull group of children. The smallest percentage of shifthandedness is apparent in the Normal Group with the Twin Group showing a percentage midway between these two former groups. In each case a higher percentage of boys than girls showed inconsistency on the two tests in composite score or 'shifthandedness' as it has been classified for the purpose of this investigation.

From the percentages found with each subgroup the suggestion is that a greater amount of shifthandedness tends to occur among the dull children or twins than in a normal group. It may be that greater stability or consistency is found among normal children and that with these groups of

dull and twin children more are innately lefthanded than observation indicates. This particularly applies to the boys in each group. Previous investigators have postulated more lefthandedness among twins and among defective or dull children as compared with normal. The percentages of shifted sinistrals in the groups would agree with these findings.

In estimating the effect on schoolwork of shift of hand the hypothesis of independence was set up, namely that shifthandedness does not affect the ability of a child. Tables with one degree of freedom were set up and figures for RH and LH children tested by means of the $X^2$ test. The groups were then compared with each other. Table 72 presents the data, boys and girls separately (for numbers on which Table 72 is based see Table 16, Appendix B)

Table 72.

Significant values are marked as formerly at the .05, .01 and .001 levels.

$X^2$ values for Shifthandedness.

| | Boys | | Girls | |
|---|---|---|---|---|
| | RH | LH | RH | LH |
| Normal with Twins $X^2$ = | 1.548 | .102 | 2.107 | $19.984^{xxx}$ |
| Normal with Retarded $X^2$ = | $3.987^{x}$ | .256 | .409 | $20.784^{xxx}$ |
| Twins with Retarded $X^2$ = | $9.512^{xx}$ | .041 | $4.338^{x}$ | .668 |

The results indicate that with the righthanded group of boys there is a tendency for shift of hand to cause retardation but no inference can be drawn from the lefthand group of boys as too few of the group were native lefthanders. Although the Twin and Retarded girls are significantly different from the Normal girls, no inference can be drawn. It would appear that some other factor is involved.

From the figures no definite conclusion can be drawn that shift of hand causes retardation but it is possible that the effect may be an indirect one. Shift of hand may be operating on some unknown factor which in turn may be influencing achievement.

It has been estimated by Hildreth 1949 (43) that developmental difficulties arise associated with handedness.

Negative characteristics and resistance are frequently encountered in children whose handedness has been changed or who exhibit imperfectly converted sinistrality. A greater percentage of lefthandedness has been noted among children who are temperamentally neurotic and among those who are not submissive. Burt (11).

It is not therefore improbable that shift of hand may be involving a temperamental factor, the influence of which is particularly noticeable with the boys.

## Summary of Shifthanded Group Investigation.

One quarter of the Total Laterality Group exhibit shift of hand or inconsistency in the Performance and Van Riper Tests.

The mean intelligence level of the group approximates to low average.

The greatest amount of inconsistency is found with the dull children.

More boys than girls show shift of hand.

No definite conclusion can be drawn that shift of hand causes retardation although there is a strong suggestion that this is so with the boys.

## References.

43. Hildreth G. 1949 - The Development and Training of Hand Dominance. J. Genet. Psych. 1949 - 75.

11. Burt C. 1950 - The Backward Child. Univ. London Press. (Third Edition) Vol. 2 P. 270 - 359.

## Chapter 11.

## Twins in Family Pairs.

In the total Twin Group were 300 children or 150 pairs. In families these 150 pairs comprised:-

| | |
|---|---|
| Boys Twins | 43 pairs |
| Girl Twins | 49 pairs |
| Boy and Girl Twins | 58 pairs. |

(A)

The level of group intelligence for these sets of twins was ascertained by computing the mean 2nd I.Q. and standard deviations.

The results are as follows:-

Twins in Family Pairs.

| | | | |
|---|---|---|---|
| Boy Twins | Mean 2nd I.Q. | = | 101.59 ± 1.94 |
| | S.D. | = | 18.05 |
| Girl Twins | Mean 2nd I.Q. | = | 97.76 ± 1.72 |
| | S.D. | = | 17.00 |
| Boy and Girl Twins | Mean 2nd I.Q. | = | 104.71 ± 1.64 |
| | S.D. | = | 17.65 |

Figs. 24, 25 and 26 present the histograms of the frequency distributions of the 3 sets of twins.

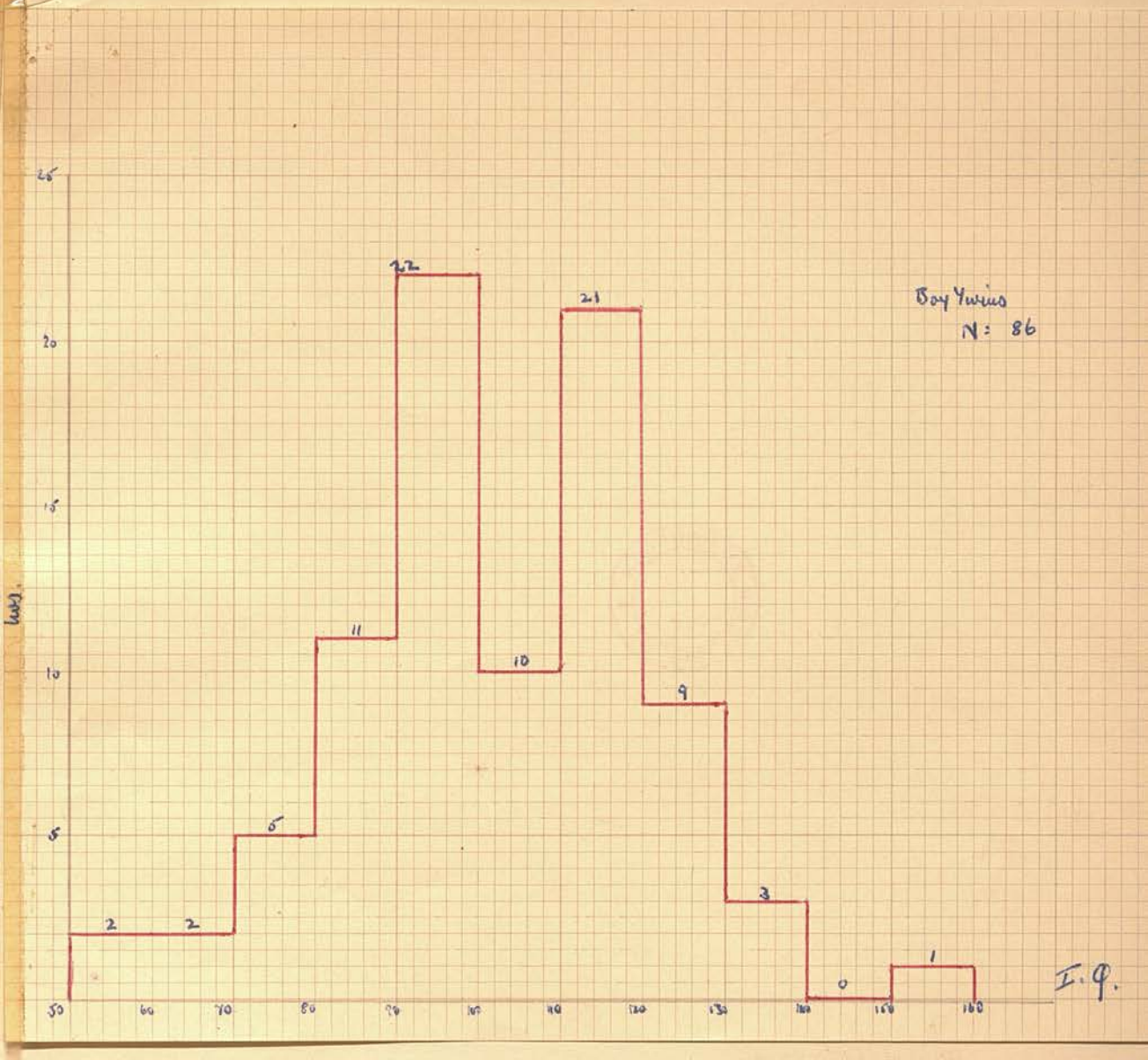



Fig. 24.

Boy Twins in Family Pairs.

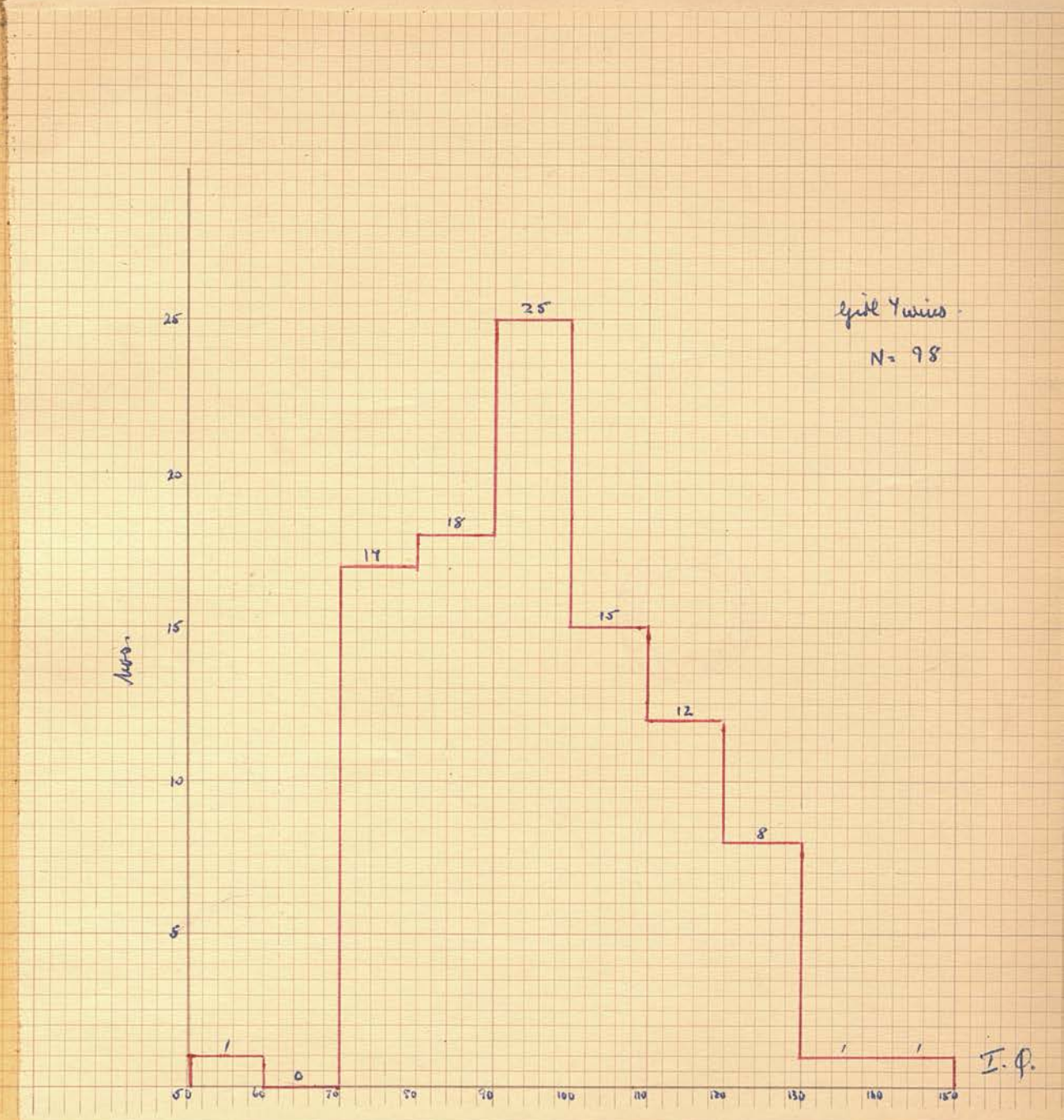



Fig. 25.

Girl Twins in Family Pairs.

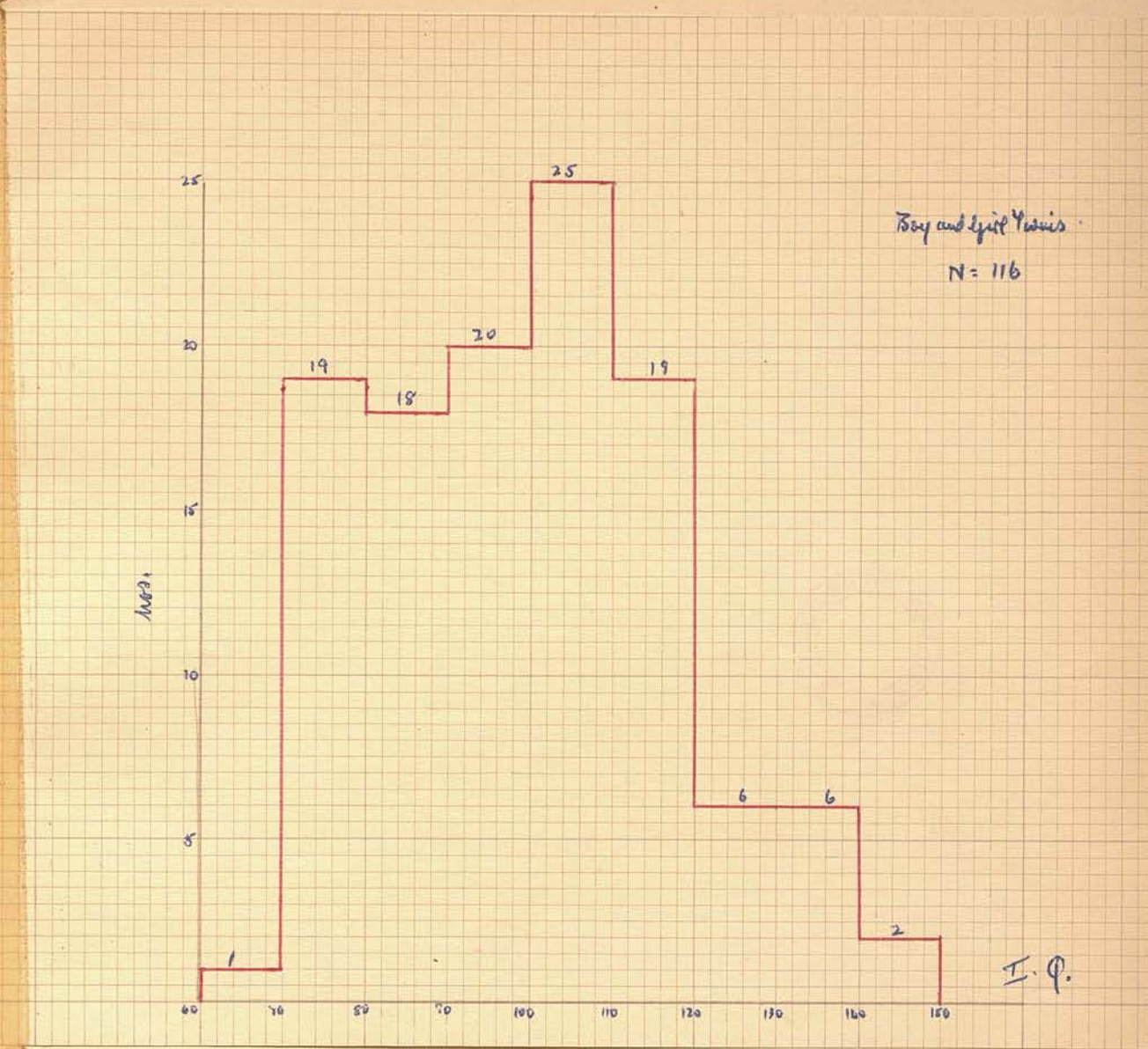



Fig. 26.

Boy and Girl Twins in Family Pairs.

The intelligence levels of the like sexed twins are lower than for unlike sexed twins. If the latter are regarded as siblings then the lower levels of the Boy Twins and Girl twins are in keeping with previous findings of twins compared to normal populations of boys and girls.

The boy twins in family pairs appear to be of higher intelligence than the girl twins although both levels are below boy and girl twins as a group. The result is also in keeping with the original finding in this study when the total twin group of 344 were analysed re intelligence. There the twins were found to be of lower level than non-twins while the boy twins were of significantly higher level of intelligence than the girl twins.

(B)

The Accomplishment Quotients were calculated for the three sets of twins in order to ascertain whether boy, or girl, or mixed twins were achieving at different levels.

Table 73 presents the findings.

Table 73.

Mean 2nd A.Qs. for twins in family pairs.

| | | |
|---|---|---|
| Boy twins | Mean 2nd A.Q. | 87.75 |
| | S.D. | 6.5 |
| Girl twins | Mean 2nd A.Q. | 92.87 |
| | S.D. | 5.65 |
| Boy and Girl twins | Mean 2nd A.Q. | 91.83 |
| | S.D. | 6.75 |

The girl twins appear to be doing better work than the boy twins while mixed twins approximate to the girl

twins in achievement. In relation to mean intelligence level the mixed twins are doing poorer work while the boy twins are achieving least well.

The groups of twins, girl, boy, and girl and boy were considered in terms of 'hand' alone. The numbers of pairs of twins who were both predominantly righthanded were found and percentages calculated. This was done likewise for those who showed lefthanded predominance in both pairs. These twins where one member was righthanded and the other lefthanded predominantly were found, and finally twin pairs where one member was lefthanded and the other ambi-handed and again where one member of a pair was righthanded and the other ambi were noted and numbers found. Table 74 gives these percentages for the 3 groups.

(C)

Table 74

Percentages showing:- Handedness.

| | 2R. handers | 2L. handers | 1R. 1L. hander | 1L. 1Ambi | 1R. 1Ambi |
|---|---|---|---|---|---|
| Girl Twins 49 pairs | 46.93 | 12.24 | 34.69 | 2.04 | 4.08 |
| Boy Twins 43 pairs | 55.81 | 6.97 | 32.55 | 2.32 | 2.32 |
| Boy and Girl Twins -58 pairs | 55.17 | 5.17 | 29.31 | 5.17 | 5.17 |
| All Twins in Family Pairs 150 pairs | 52.66 | 8.00 | 32.00 | 3.33 | 4.00 |

The highest percentages with all the twins in family

pairs is found where both twins show predominance of the right hand. This is followed by a group where one twin is righthanded and the other lefthanded. The girl twins showing two lefthanders present a much higher percentage than for the boy twins, the percentage for the boy twins being only half as great as that shown for the girls. The percentages where one twin is an ambi-handed child and the other right or left are approximately equal in boy twins and boy and girl twins, but the girl twin group alone shows a high percentage for one twin being righthanded while the other is ambi.

The high percentages for righthanded twins may be due to the fact that twins like other children succumb to pressure for conversion from left to right. The trend in general agrees with previous findings where studies have been made of the incidences of handedness in twins but many studies have been concerned with 'infant' twins, thus by reason of age, results tend to show a large incidence of lefthandedness and ambilaterality. Newman studied 50 twin pairs and found 25 pairs were both righthanded, 11 were both lefthanded, 12 pairs showed 1 member left and 1 right and in 2 cases both members were ambidextrous. Gesell studied 253 pairs of young identical twins and found at least 25% manifested sinistrality. This figure approximates to that found for non-twin infants below 2 years of age. Gordon 1920, studied the handedness of school age twins and found in 59 pairs of boy twins, 47 pairs were both righthanded,

none showed lefthandedness and 12 pairs showed one member right and one member left. In girl twins alone where he studied 79 pairs, 69 were both righthanded, 1 pair only showed both to be lefthanded and 9 pairs where one was right and the other left. In 81 pairs of boy and girl twins which he studied, he found 53 both righthanded, 3 both lefthanded and 25 where one was right and the other lefthanded. Dahlberg of Stockholm 1926 studied 124 twin pairs. He found of these, 89 pairs were both righthanded, 6 pairs were both lefthanded, while 29 pairs showed 1 member right and 1 member left.

The trend thus agrees with the percentage found for these 150 pairs in that most show both members to be righthanded - a middle group show 1 member right and 1 member lefthanded while a smaller group show both members to be lefthanded. A few investigators have found a very small percentage to be ambidextrous.

The Eyedness of the twins in family pairs was considered in a similar fashion to the handedness. The number and percentage of righteyed twin pairs was found and likewise the number and percentage where both members showed left eye dominance. Finally the numbers and percentage of pairs where one member showed right eye dominance and the other left eye dominance.

Table 75 presents the data.

Table 75.

Percentages showing:- Eyedness.

| | 2 Righteyed | 2 Lefteyed | 1 Right and 1 Lefteyed |
|---|---|---|---|
| Girl Twins | 44.89 | 8.16 | 46.93 |
| Boy Twins | 34.88 | 16.27 | 48.83 |
| Boy and Girl Twins | 44.86 | 13.77 | 41.37 |
| All Twins in Family Pairs | 42 | 12.66 | 45.33 |

The highest percentage for all the twins in family pairs lies with the group where one twin is righteyed and the other lefteyed. This trend is noted in the boy twins alone and in the girl twins alone but not in the boy and girl twins. This latter group show the highest percentage where both twins show predominance of right eye. This would tend to suggest that as boy and girl twins are siblings they show the trend of the average non-twin. The high percentage with like sex twins is interesting in the suggestion it holds of the operation of an asymmetry mechanism as postulated by Newman. Of interest also is the fact that girl twins show both to be lefteyed much less frequently than boy twins in this group, the percentage of the boy twins being double that for the girls.

Rife (84) in his study of ocular dominance in identical twins reported that out of 20 pairs, 15 pairs were cases of partial or complete reversal, i.e. 1 member

was righteyed and the other lefteyed. This would agree with the general trend found for this group of boy twins and girl twins. Raney 1938 (82) found on his phi-test, that in practically every case of identical twins, one twin was right dominant and the other left dominant for eyedness. Such reversals however did not occur on other laterality tests he used, but tended to show therefore that identical twins were not in reality identical at all but that in the nervous mechanism there was an underlying tendency for one twin to be the mirrored counterpart of the other. On his ocular dominance test he found 24% twins where one member was righteyed, 29% where both were lefteyed and 6% where one was left and the other ambi-eyed.

(D)

Owing to the nature of selection of the twins no data was available to indicate which might be identical and which were non-identical. Intelligence level and scholastic achievement together with physical similarity were not considered sufficiently reliable indications as the individual pairs differed so widely. Accordingly they were classified as boy, girl, and boy and girl pairs. The latter type are obviously non-identical. It was possible however to ascertain which was the firstborn twin and this one was considered as the 'older' while the second born was classified as the 'younger'.

The laterality of the twins was thus investigated in terms of older and younger twins among family pairs. The hand and eye of the twins was investigated by means of the $X^2$ test to find any association, e.g. if the older twin was RHRE could one assume that the younger would be also? The association was investigated over the complete combinations of hand and eye, i.e. RHRE, RHLE, LHRE, LHLE, Ambi-RE and Ambi-LE.

Secondly the righthanded twins were compared with the lefthanded to find any association. Could one postulate that if the older twin was righthanded the younger would be lefthanded or vice versa.

Thirdly the righteyed twins were compared with the lefteyed twins again to investigate any possible association. Thus if one twin was righteyed was one justified in assuming the other twin would be lefteyed?

Fourthly the twins showing pure dextrality or pure sinistrality were combined and regarded as a 'pure' group.

These were compared with crosslateral twins to find if any association was present. If the older or younger twin was in the 'pure' group would the other younger or older twin be in the crosslateral category? Finally the two types of crosslateral hand and eye combination were examined to find any association between older or younger twin. If one was RHLE could one determine the other to be LHRE?

Table 76 indicates the results of the $X^2$ test for these twins investigated in family pairs.

Table 76.

| Categories | Complete | RH/LH | RE/LE | Pure/Cross |
|---|---|---|---|---|
| Boy twins | 20.660 | .325 | .005 | 2.930 |
| Girl twins | 22.341 | 1.033 | .271 | .007 |
| Boy and girl twins | | | | |
| Boys older | 14.421 | .223 | 0 | .733 |
| Girls older | 17.750 | .040 | .765 | 2.334 |
| Total | 24.832 | .138 | .470 | 2.559 |

In the boy and girl twins the group were examined where (a) the boy was the older twin and (b) where the girl was the older twin.

None of the values is significant at the .05 level, although the Pure/Cross comparison is high (probability about .10)

There appears little association of Laterality in these twins between older and younger with the exception of Pure/Cross which shows some association. Thus if the older twin is a pure sinistral or pure dextral then there is a tendency for the younger to be a crosslateral.

The figures showing the frequencies for the sets of twins on which Table 76 is based can be found in Appendix B (Tables 17 - 20). Each table has 25 degrees of freedom, and by the figures in these tables the association between the handedness and eyedness of the younger and older twins was measured, taken in family pairs.

The special characteristics were examined also from the figures in the appendix, e.g. for handedness alone,

by adding the figures in the appropriate cells. These $X^2$ for such special groups were used to test handedness, eyedness and cross with pure..

(E)

Correlation Coefficients of Twins in Family Pairs.

The correlation coefficients of the twins in family pairs for older with younger were calculated for boy twins, girl twins and boy and girl twins. Table 77 gives the data indicating the correlation for 2nd Intelligence test result and 2nd Accomplishment Quotient.

Table 77.

Correlation coefficients, older with younger twins.

| | I.Q. | A.Q. |
|---|---|---|
| Boy twins | .764$^{xxx}$ | .673$^{xxx}$ |
| Girl twins | .770$^{xxx}$ | .665$^{xxx}$ |
| Boy and girl twins | .630$^{xxx}$ | .337$^{xx}$ |

These correlations are all significant at the .001 level with the exception of the boy-girl twin group on A.Q. which is significant at .01 level.

Thus the association between twins regarding intelligence test result and accomplishment quotient is high. The association between twins of like sex is higher than between the twins of unlike sex. The lower correlation on attainment for boy and girl twins may be sex

influenced as boys were previously noted to be consistently and significantly poorer than girls.

This finding of higher association between twins of like sex is in agreement with C. Merriman's findings 1924 (64) where he computed the correlation ratios of like and unlike sexed twins. He found the ratio of twins of like sex higher than the ratio for unlike sex. Similarly Lauterbach in 1925 (54) found that twins are more closely linked than ordinary siblings. Thorndike first used tests in his study of twins and came to the conclusion that the similarity of twins was inherent rather than acquired. He compared twins of 9 - 11 years with twins 12 - 14 years but found no greater similarity between his older twins than between his younger. He concluded thus that environment does not exert such a difference.

(F)

Twins compared for Intelligence Test differences and Accomplishment Quotient differences.

The Twins were taken in family pairs and 't' values were calculated to see if there was any significant difference in A.Q. or I.Q. between younger and older twins.

No significant differences were found.

Table 78 presents the data.

Table 78.

2nd I.Q. Older with Younger Twins.

| | | |
|---|---|---|
| t-values | Girl Twins | 0.164 |
| | Boy Twins | 0.505 |
| | Girl and Boy Twins | 1.549 |
| | All Twins Older and Younger | 0.905 |

2nd A.Q.

| | | |
|---|---|---|
| t-values | Girl Twins | 0.875 |
| | Boy Twins | 1.365 |
| | Girl and Boy Twins | 0.102 |
| | All Twins | 0.340 |

(G)

Difference between Twins in Family Pairs.

Having considered the 'association' of hand and eye among this group of twins in family pairs, an investigation was made to find any 'difference' in the proportions of twins with handedness and eyedness. Thus the frequencies were tested again by the $X^2$ test to see if, e.g. more older twins showed lefthand tendency than younger twins or whether more older twins might be

righteyed than younger etc.

The differences were investigated over the complete combinations of hand and eye, i.e. RHRE, RHLE, LHRE, LHLE, ambi-RE, ambi-LE for the boy twins, for the girl twins and for the boy and girl twins - all in the categories of older and younger.

From the following figures the proportion of younger and older twins with the varying characteristics could be tested, younger with older, to see if there was any significant difference.

Boy Twins

| | RHRE | RHLE | LHRE | LHLE | AMBI RE | AMBI LE | |
|---|---|---|---|---|---|---|---|
| Younger | 17 | 13 | 8 | 4 | - | 1 | 43 |
| Older | 19 | 14 | 6 | 3 | 1 | - | 43 |
| | 36 | 27 | 14 | 7 | 1 | 1 | 86 |

With 5 degrees freedom

$$X^2 = 2.597$$

The value is not significant, hence there appears to be no difference in the Boy Twins between older and younger members as regards characteristics of Hand and Eye.

Girl Twins

| | RHRE | RHLE | LHRE | LHLE | AMBI RE | AMBI LE | |
|---|---|---|---|---|---|---|---|
| Younger | 21 | 11 | 9 | 7 | 1 | - | 49 |
| Older | 26 | 7 | 8 | 6 | 2 | - | 49 |
| | 47 | 18 | 17 | 13 | 3 | - | 98 |

With 5 degrees freedom

$$X^2 = 1.144$$

The value is not significant. There therefore appears to be no difference among the group of girl twins - older and younger members with regard to combinations of hand and eye.

Boy and Girl Twins (Boys Older, Girls Older)

| | RHRE | | RHLE | | LHRE | | LHLE | | AMBI RE | | AMBI LE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Younger | 9 | 15 | 10 | 8 | 1 | 8 | 2 | 2 | 2 | 1 | - | - | 24 | 34 |
| Older | 11 | 19 | 6 | 6 | 5 | 3 | 2 | 3 | - | 2 | - | 1 | 24 | 34 |
| | 20 | 34 | 16 | 14 | 6 | 11 | 4 | 5 | 2 | 3 | - | 1 | 48 | 68 |

With 5 degrees freedom. The left hand columns show frequencies where the boy is older: the righthand columns show frequencies where the girl is older.

$X^2$ = Boys 5.717
Girls 4.763
Boys and Girls 3.237

The values are not significant. Thus there is no difference in the group of Boy and Girl Twins older and younger members with respect to combinations of hand and eye.

Twins where the boys were older were compared with twins where the girls were older in the following table.

Boys and Girls

| | RHRE | RHLE | LHRE | LHLE | AMBI RE | AMBI LE | |
|---|---|---|---|---|---|---|---|
| Boys older | 20 | 16 | 6 | 4 | 2 | - | 48 |
| Girls older | 34 | 14 | 11 | 5 | 3 | 1 | 68 |
| | 54 | 30 | 17 | 9 | 5 | 1 | 116 |

With 5 degrees freedom

$$X^2 = 3.191$$

This value is not significant; thus no significant difference was found between the twins where the boys were older and the girls older with respect to combinations of hand and eye.

From the foregoing tables the appropriate frequencies were drawn to test for difference in handedness between the twins, e.g. do younger twins show a greater proportion of lefthandedness than older twins, or vice versa?

e.g.

| Boy Twins | Righthand | Lefthand | |
|---|---|---|---|
| Younger | 29 | 12 | 41 |
| Older | 33 | 8 | 41 |
| | 62 | 20 | 82 |

With 1 degree freedom

$$X^2 = 1.058$$

The value is not significant; thus no difference was found in the proportion of handedness between the older and younger twins in the Boys Group.

This examination was also made for eyedness and again a 'pure' group, i.e. RHRE and LHLE were compared with

crosslaterals among younger with older twins. Table 79 presents the $X^2$ values for these complete combinations of hand and eye and for handedness, eyedness and pure with cross.

Table 79.

| | Complete | RH/LH | RE/LE | Pure/Cross |
|---|---|---|---|---|
| Boys | 2.597 | 1.058 | .069 | .049 |
| Girls | 1.144 | .453 | 1.180 | .425 |
| Boys and Girls Boys older | 5.717 | .611 | 1.371 | .091 |
| Girls older | 4.763 | .800 | - | 1.148 |
| Boys and Girls Total | 3.237 | .056 | .611 | .991 |
| Boys and Girls, pairs in which boys older c.f. with pairs where girls older. | 3.191 | .685 | 3.666 | 1.281 |

No significant differences were found.

Finally all the twins were taken together to find if there were any significant differences in numbers of different categories of hand and eye in older and younger. Results are -

| Categories | Complete | RH/LH | RE/LE | Pure/Cross |
|---|---|---|---|---|
| All Twins | | | | |
| Older/Younger | 2.792 | 1.200 | .146 | 1.202 |

None of the foregoing values are significant. Thus there is probably no difference in handedness and eyedness between younger and older twins, i.e. in the long run the numbers of older and younger twins showing left and right

tendencies are in the same proportions.

Groups of Twins.

Finally for handedness, eyedness and crosslaterals with 'pure' groups the Groups of twins were tested one with the other to find if there was any difference within the groups.

Tables of 1 degree of freedom were set up, e.g. Boy Twins with Girl Twins.

| | RH | LH | | RE | LE | | Pure | Cross | |
|---|---|---|---|---|---|---|---|---|---|
| Boys | 63 | 21 | 84 | 51 | 35 | 86 | 43 | 41 | 84 |
| Girls | 65 | 30 | 95 | 67 | 31 | 98 | 60 | 35 | 95 |
| | 128 | 51 | 179 | 118 | 66 | 184 | 103 | 76 | 179 |
| $X^2$ = | | 1.090 | | | 1.636 | | | 2.443 | |

The results from the groups are as follows in Table 80.

Table 80.

Sets of Twins compared.

| | RH/LH | RE/LE | Pure/Cross |
|---|---|---|---|
| Boy Twins with Girl Twins | 1.090 | 1.636 | 2.443 |
| Boy Twins with Boy and Girl Twins | .638 | .817 | .718 |
| Girl Twins with Boy and Girl Twins | 2.247 | .195 | .617 |

None of these $X^2$ values are significant; thus there is no difference in these frequencies for the girl twins, boy twins and boy and girl twins: the numbers in each group showing tendencies of hand and eye are the same as far as can be deduced from the data.

The figure of 3.666 for RE/LE in Table 79 boy and girl twins in which pairs of twins in which the boy is older are compared with pairs in which the girl is older is surprising (probability nearly .05). This figure is the one exception to the 'no relations' of the other figures and seems to suggest that the eyedness of boy and girl twins depends upon which is the older twin, a boy or a girl.

## Summary of Twins in Family Pairs.

Like-sexed twins were found to be of a lower level of intelligence than unlike sexed twins with the boy twins as a group, of higher level than the girl twins.

The twins in family pairs were considered re hand. The trend follows previous investigations with highest incidence for both members being righthanded. A second high percentage where one twin is righthanded and the other lefthanded is found with lower percentages where both members are lefthanded.

The girl twins as family pairs show high incidence where two members are lefthanded.

The twins were considered re eyedness. Highest percentages were found where with like-sexed twins one twin was righteyed and the other lefteyed.

This trend was not found in unlike-sexed twins.

The Accomplishment Quotients showed performance below potential. Boy twins as a group were achieving at lowest level compared with capacity.

The association between older and younger twins re hand and eye was examined on the $X^2$ test. No significant values were found. Thus one cannot say that if one twin is righthanded the other will be too or if one is righthanded the other will be lefthanded.

The correlations found on I.Q. and A.Q. were all highly significant and higher between like-sexed twins

than unlike-sexed twins.

Comparison of twin groups to find significant intelligence test and achievement test differences between older and younger revealed no significant differences among the groups.

The laterality of twins in pairs was examined to find if any significant differences emerged with regard to combinations of hand and eye. The older twins were compared with the younger twins in the groups of Boy, Girl and boy and girl twins.

No significant difference emerged for any of the groups.

Differences between the older and younger twins with regard to hand alone, eye alone and pure dextrals and sinistrals compared with crosslaterals were examined. No significant differences emerged.

All the twins older and younger were examined over the foregoing combinations but no significant difference emerged.

Finally the groups of twins were compared with each other. No significance emerged.

The eyedness of boy and girl twins where the boy was older compared with pairs where the girl was older presented a finding almost significant at the .05 level. This would indicate that the eyedness of boy and girl twins depends upon which is the older twin, a boy or a girl.

## References.


84. Rife D.C. - Genetic studies of monozygotic twins. 111 Mirror imaging. J. Hered. 1933 - 24, 443 - 446.

82. Raney E.T. 1938 - Reversed Lateral Dominance in Identical Twins. J. Exper. Psych. 1938 - 23, 304 - 312.

69. Newman H.H. - Studies of Human Twins II. Asymmetry Reversal or Mirror Imaging in Identical Twins. Biol. Bull. 1928 - 55, 298 - 315.

30. Gesell A. 1931 - The Developmental Psychology of Twins. In 'A Handbook of Child Psychology' (C. Murchison Ed.) Worcester Mass. Clark Univ. Press 1931.

35. Gordon H. 1920 - Lefthandedness and mirror writing especially among defective children. Brain 1920,- 43, 313 - 368.

19. Dahlberg S. 1926 - Twin Births and Twins from an hereditary point of view. Stockholm 1926.

64. Merriman C. 1924 - The Intellectual Resemblance of Twins (Psychological Monographs - Vol 33, No. 5) Princeton N.J. Psychological Review Co.

54. Lauterbach 1925 - Studies of Twin Resemblance. Genetics 1925 - 10, 525 - 568.

## Conclusion of Laterality Analysis with Intelligence and Achievement.

From the preceding results it would seem proved that laterality in all the variations of hand, dextral sinistral and crosslateral has no significant relationship with the intelligence of the individual. Children of high intelligence and children of low intelligence are alike in that manifestations of laterality can occur in them in various forms. This is true of the different types of children, dull normal and children of a twin population. Yet general patterns of Laterality distinguish these groups differing in intellectual level. The Normal and Twin Group show similar mean intellectual levels approximating to average grading and with these groups more coincidence of hand and eye was found particularly with the Twins. The Retarded Group which is of dull intellectual level revealed less coincidence of hand and eye and much greater percentages of crosslaterality. Likewise the boys in each group revealed much greater incidence of mixed hand and eye than did the girls, although no significant sex difference was found. The trend in the Total Group pointed to children who were righteyed being superior in intelligence to those who were lefteyed. In a consideration of the Eyedness of the groups it was found that the highest percentage of

lefteyed children was in the Retarded Group. Thus this tendency may relate to the group sampling as the greatest numbers of righteyed children were in the two subgroups of higher mean level of intelligence.

Similarly no significant relationship was found established with the laterality of the groups and their achievement in educational tests of reading and spelling. Girls showing coincidence of hand and eye were found, to be working at a higher level than girls who were 'mixed' in hand and eye. This was not characteristic of the boys. The boys in the Twin Group showed the reverse of this tendency as the lefthanded twin boys were found to be working at a higher level than the righthanded twin boys. Likewise the crosslateral twin boys showed a higher level of achievement than the twin boys showing coincidence of hand and eye. The consistency of hand and eye among the girls may be contributing to the higher achievement observed when compared with the crosslateral categories of girls. This tendency is not found operating significantly with the boys and therefore cannot be considered as a major factor of the higher achievement - indeed the reverse is the case with the Twin boys.

The earlier analysis of the retardation situation revealed that the boys were working at a level significantly poorer than the girls. In these subgroups, the boys continue to achieve at a lower level than the

girls. Other factors must therefore be operating more strongly with the boys to explain this poorer achievement, since no significant sex difference in laterality was found.

The measurements found are quantitative. It is difficult indeed to assess qualitative effect but it is possible that if hand and eye are not factors operating directly on achievement or intelligence, they may nevertheless be exerting indirect influence. Is it possible that this indirect influence may be observed in 'temperament'? An analysis has therefore been made in a later chapter of Laterality and temperament.

## Chapter 12

## Laterality and Speech.

Handedness and speech function have been investigated by many writers, who postulate a close association between the two. Anthropological evidence suggests that there is a fundamental connection in the history of the race between rise of speech and emergence of hand dominance. Speech and gesture are both phases of expressive movement and thus stutterers or those with allied speech defects show marked disturbance of motor function. In cases of aphasia, (i.e. interference with language functions, speech, reading and writing) the injury is usually in the hemisphere opposite to the patient's dominant hand, and it has been claimed that right-sided lesions seldom result in aphasia because few persons are left-handed or left-sided in lateral dominance. Thus change in hand or shifted sinistrality tends to be considered as one feature associated with speech difficulties. A lack of consistent handedness or delay in establishing dominance, particularly with young children, may lead to disorders in speech function. It has been found that stuttering is more prevalent in children than in adults. Travis 1931 (100) in his investigations postulates that 1% of the school population stutters, with boys far outnumbering girls. The proportion varies from 3 to 1 to 8 to 1, depending on

age. Stuttering likewise has been correlated with lefthandedness by many investigators, and is frequently reported as an accompaniment of changed handedness.

In order to study these characteristics in our group of 770 children, speech defects were noted as the children were being examined. The defects varied from severe stutter and stammer, through hesitations in speech to defective pronunciation of sounds and letters, with e.g. inability to pronounce the letter 'r' or 's'. These variations in difficulty were classified under one general heading as 'speech difficulty'.

It was found that from the Total Laterality Group of 770 children, 51 children or 6.62% showed speech difficulties. An interesting factor is that from this number 2.20% were children who showed shift-hand tendencies as recorded on the Performance tests and Van Riper. Likewise more boys than girls were found with speech difficulty. In the Total group 7.69% of the boys group and 5.27% of the girls group showed speech disorder.

In the Subgroups, the Retarded and Twin Groups showed approximately similar total percentages while fewer cases of speech disorder were found in the Normal Group.

In the Retarded Group 7.89% of the Boys and 7.27% of the Girls showed difficulty with 7.66% for the total Retarded Group. Among the boys, 7 cases were found in the pure dextral category, i.e. RH/RE, while 8 cases were found in the crosslateral categories, most being in the lefthanded

righteyed group. No cases were found in the pure sinistral group i.e. LH/LE. With the girls only two cases were found in the pure dextral category. Three cases were found in the crosslateral categories, while three cases were found among the pure sinistral group. No cases were found in either ambi-group for boys or for girls. Of the total of 15 boys in the Retarded Group who showed speech disorder, six cases were shift-hand types while two of the eight girls were also cases of shifted hand.

With the Twin Group a similar picture was found. The percentage of children showing speech disorder for the entire Twin Group is 7.33% with 9.02% of the boys group being involved and 5.76% of the girls. Thus as with the Retarded group more boys than girls showed speech difficulty. Among the twin boys, four cases were found in the pure dextral category and two cases were found in the pure sinistral category while seven cases were observed in the crosslateral categories with more in the lefthanded righteyed group than righthanded lefteyed. With the girls, four cases were likewise found in the pure dextral category, with again two cases, similar to the boy twins, in the pure sinistral category. Three cases were found in the crosslateral righthanded lefteyed group but no cases in the lefthanded righteyed group. As with the Retarded group, no cases were found in the ambi categories. Of the total of thirteen twin-boys who showed speech disorder, four of these entered the shifthanded category, while of the nine cases of girl twins who showed speech disturbance, two

were cases of shifted hand.

Fewer cases of speech disturbance were found in the Normal Group although, as with the Twins and Retarded groups, more boys than girls were observed. Of the total Normal group 3.52% of the group showed speech disturbance, 5.26% of the boys group and 1.33% of the girls group. With the boys only one case was found in the pure dextral category with two cases in the pure sinistral category. Likewise two cases were observed in the crosslaterals, one from each classification of crosslateral. With the girls only one case was observed and this girl was found in the pure sinistral group. Of the total of five boys in the Normal Group who showed difficulty, two were cases of shift-hand, while the single girl case was also one of shifted hand.

The association of shift-handedness with all the groups is thus striking being one third of the total percentage for the complete group of 770.

Likewise a high percentage of the cases is associated with the crosslaterals. Of the total of 51 children who showed speech difficulty 35.29% were found in the RHRE or pure dextral category, 45.09% were found in the cross-lateral categories, i.e. RHLE and LHRE, while 19.60% were found in the pure sinistral category, i.e. LHLE. Thus speech disorder appeared less frequently where dominance was consistent or where coincidence of hand and eye was present in either the dextral or sinistral category.

It was desirable to find out if speech disorder such

as was recorded was significantly related with shift-handedness in general. Secondly it was desirable to find if this relationship was true for each group of boys and girls considered separately. Lastly was the relation more marked for boys than for girls and more significantly for perhaps the twin group than for the Normal group. Accordingly the numbers of children found in each hand-eye category were examined for significance by the $X^2$ test. Table 81 presents the $X^2$ values for each of the subgroups Normal, Twins and Retarded and for boys and girls separately. The figures on which these values are based can be found in Appendix B Table 21.

Table 81.
$X^2$ values.

| | Boys | Girls |
|---|---|---|
| Normal Group | 0.752 | 13.59$^{xxx}$ |
| Twin Group | 0.366 | 0.00 |
| Retarded Group | 1.184 | 0.00 |
| Total | 2.151 | 0.773 |

Total Boys + Girls 3.268

As a whole the Total group, i.e. all boys + all girls shows a value of 3.268 which is almost significant at the .05 level. This is probably the most reliable value owing to the greater number in the speech difficulty cells. Hence a conclusion can be drawn that there is a

suggestion of an association between shifthandedness and speech difficulty.

The one significant value is that for normal girls but as small numbers were in the cells this value must be accepted with caution.

On the whole the figures do not strongly support the thesis of speech difficulties being associated with shift of hand but neither do they disprove it.

This suggestion of an association would appear to agree with previous investigators. Sinistrals as a class have not been found to be inferior to righthanded in verbal expression but speech disorders appear frequently with dextro-sinistral cases or cases where an attempt has been made to shift the hand. Ballard 1911 (5) found among 322 lefthanded children that 51 pure sinistrals showed no speech difficulty, but of 271 dextro-sinistrals, 17% stammered and approximately 26% had stammered in the past. Bryngelson and Clark 1933 (10) found that in an investigation of schoolchildren, 81% who stuttered had also suffered from shift in hand from left to right. A large percentage of stutterers would appear to be ambidextrous or show no definite dominance. Few cases were found in the ambi groups in the present study, but the highest percentage of children with speech disturbance was found in the dull group or Retarded group. They likewise as a group exhibit the highest percentage of crosslaterality or mixed hand and eye with the highest percentage of shift of hand. Burt

1937 (11) found that speech disorders arose primarily in association with learning to write and thus an association with the motor areas of the brain is postulated. Gordon 1920 (35) states that stuttering is not to be looked for in a pure sinistral child but in the child incompletely or unsuccessfully shifted in hand from left to right.

Many other investigators e.g. Chrysanthis 1947 (13) Daniels 1940 (20) Haefner 1929 (36) Oates 1927 (72) Wallin 1916 (108) have found a relationship between sinistrality and change of hand. Whether the relationship between hand and speech is causal or associative is difficult to establish as results tend to vary with age level. A more significant relationship between handedness, lack of dominance and speech may emerge at an early age among children but investigations have stressed in some cases little relationship at an older age.

The present group of children average chronologically an 11 year level and with them there appears no strong relationship between shift of hand and speech. If speech difficulties occur in children when they first begin to write due, as has been stated by Burt 1950 (11) to conflicting tendencies between what the child wishes to say and what he writes - confliding tendencies relating to one and the same sphere of mental activity - then it would appear that with maturation this conflict is

resolved by the time the child reaches the end of his primary schooling. If, however, the speech difficulty persists, with the strengthening of habit speech disorders in children of older years may become complicated by the overlay of all the attendant emotional difficulties and frustrations which face these types of children and which delay recovery. Yet a major underlying factor from earlier years may be this early interference with the motor functions and consistent dominance of the individual, such that a conflict of writing and speech may never be resolved. This will be the more apparent when development is slow and immaturity is present as with dull children. The highest percentage of crosslaterality or mixed dominance is found in the dull group of children. This may point to poorly integrated nervous mechanism or lack of stability such that a child fumbles not only with his hands but with his speech as manual acts and speech are simultaneously conditioned. Thus a conflict of speech with crossed hand and eye or shifted hand may be perpetuated for a longer period of time than if natural coincidence of hand and eye is shown where more integration is present in the nervous mechanism. The spatial confusion and negative reactions which have been found with children who have been shifted in hand tend to build up tensions which may be released in the form of stuttering reactions as well as conflict over one sphere of mental activity.

Further work is undoubtedly required in this field but the present findings with this group tend to suggest slight relationship with shift of hand. There are many factors involved in the question of speech difficulty. Manual inconsistency may be fundamental by reason of the interference in brain mechanism when the child is in a formative stage during growth.

## References.


5. Ballard P.B. 1911 - Sinistrality and Speech. J. Exper. Ped. 1911 - 12 - 1, 298 - 310.

10. Bryngelson B. and Clark T.B. - Lefthandedness and Stuttering. J. Hered. 1933 - 24.

11. Burt C. 1950 - 3rd Edition The Backward Child. New York, MacMillan 1937.

35. Gordon H. - Lefthandedness and Mirror-writing, especially among defective children. Brain 1920 - 43, 313 - 368.

13. Chrysanthis K. - Stammering and Handedness. Lancet 1947 - 252, 270 - 271

20. Daniels E.M. - An Analysis of the relation between handedness and stuttering with special reference to the Orton-Travis Theory of Cerebral Dominance. J. Speech Dis. 1940 - 5.

36. Haefner R. - Education. Significance of Lefthandedness. Contbn. to Education No. 360 New York, Bureau of Publications. Teachers College Columbia University 1929.

72. Oates D.S. - Lefthandedness in relation to Speech Defects, Intelligence and Achievement. For. Educ. 1929, 7.

108. Wallin J.E.W. - Census of Speech Defectives among 89,057 Public School pupils. A Prelim. Report Sch. Soc. 1916 - 3.

100. Travis L.E. - Speech Pathology. New York. D. Appleton Century Co. 1931.

## Section III

## Chapter 13.

### Temperamental Analysis.

During the examination of the Total Laterality Group N = 770, temperamental ratings were obtained on the children from their teachers and clinicians. The teachers were asked to underline from a group of adjectives those that seemed to apply most to each individual child. Comments on their temperament were also added by clinicians who were trained psychologists. In this way 108 adjectives relating to the temperamental characteristics of the children were obtained.

While it may be argued that the ratings are subjective estimations, they were obtained from adults who were familiar with the children from day to day contact. From the nature of the study and the difficulties inherent in the field work it was impossible to deal with the temperamental aspect from any more sophisticated alternative angle, as the primary object was the study of the laterality characteristics of the children.

Thus, although the lexicon of any language is far from offering a perfect catalogue of the elements of mental life yet a cautious use of such trait names, as outlined by Burt and other workers, may reveal certain trends associated with the real topic of study - trends which could point to the need for further research. Bearing in mind the necessity for cautious interpretation the following analysis was made

of the temperamental characteristics.

The adjectives for convenience of assessment were grouped under eight different headings. There is inevitable overlapping but an attempt was made to divide the children into marked types.

Previous writers had noted an attitude of resistance with many crosslateral children or children of mixed hand and eye. Schonell 1940 (88) found in the disability cases he studied that this 'mixed' condition was associated with emotional instability, attitudes of resentment, inferiority and apathy. Wile and Davis 1941 (111) reported finding much mixed dominance in problem cases in the age range 5 to 12 in their clinic in New York.

In this present study two groups were defined. Resistant - aggressive or active, and Resistant - negative or passive. (See Appendix A, Illustration 7a for adjectives classified under each heading). The eight main headings were:-

1. Stable
2. Resistant - aggressive or active
3. Resistant - negative or passive
4. Unstable
5. Anxious
6. Inhibited
7. Delinquent
8. Neurotic and unsociable

It can be argued that all classes apart from No.1 are unstable to a degree. This is recognised and while the classifications may appear to overlap in terminology, certain distinctions have been made in types.

The percentages of temperamental ratings were calculated for each group, Twin, Normal and Retarded and in each category of hand and eye, under the 8 main headings as previously stated. This was done separately for boys and girls. Table 82 presents the data.

## Table 82.

Temperamental Rating Percentages of the Groups in categories of Hand and Eye - for boys and girls.

### Normal Group.

| | Stable | Resistant Active | Resistant Passive | Unstable | Anxious | Inhibited | Delinquent | Neurotic | |
|---|---|---|---|---|---|---|---|---|---|
| RH.RE | 68.3 | - | 1.0 | 9.9 | 12.9 | 6.9 | - | 1.0 | Boys |
| | 68.7 | 4.0 | - | 8.1 | 12.1 | 6.1 | - | 1.0 | Girls |
| LH.LE | 76.9 | - | - | 3.8 | 19.2 | - | - | - | Boys |
| | 88.9 | - | - | - | 19.1 | - | - | - | Girls |
| RH.LE | 49.3 | 1.4 | 8.5 | 8.5 | 14.1 | 15.5 | 1.4 | 1.4 | Boys |
| | 51.1 | - | 8.9 | 17.8 | 22.2 | - | - | - | Girls |
| LH.RE | 59.6 | 6.4 | 6.4 | 19.1 | 4.3 | 4.3 | - | - | Boys |
| | 81.8 | - | 3.0 | 9.1 | 3.0 | - | 3.0 | - | Girls |
| TOTAL | 62.9 | 1.6 | 4.3 | 10.3 | 11.9 | 7.9 | 0.4 | 0.8 | Boys |
| | 65.3 | 2.6 | 2.6 | 10.4 | 13.5 | 4.1 | 0.5 | 1.0 | Girls |
| | 63.9 | 2. | 3.6 | 10.3 | 12.6 | 6.3 | 0.4 | 0.9 | Boys + Girls |

### Twin Group.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| RH.RE | 45.0 | 1.2 | 6.9 | 18.1 | 18.8 | 5.6 | 1.2 | 3.1 | Boys |
| | 48.9 | 2.2 | 6.2 | 13.5 | 12.9 | 12.9 | 1.1 | 2.2 | Girls |
| LH.LE | 16.7 | 5.6 | 8.3 | 30.6 | 19.4 | 11.1 | - | 8.3 | Boys |
| | 61.0 | - | - | 4.9 | 24.4 | 9.8 | - | - | Girls |
| RH.LE | 44.9 | 3.4 | 6.7 | 15.7 | 12.4 | 13.5 | 1.1 | 2.2 | Boys |
| | 58.0 | 5.7 | 1.1 | 10.2 | 11.4 | 10.2 | 1.1 | 2.3 | Girls |
| LH.RE | 33.9 | 3.4 | 3.4 | 20.3 | 15.3 | 15.3 | - | 8.5 | Boys |
| | 55.6 | 7.9 | 4.8 | 9.5 | 15.9 | 4.8 | - | 1.6 | Girls |
| TOTAL | 40.3 | 2.6 | 6.3 | 19.1 | 16.9 | 9.7 | 0.9 | 4.3 | Boys |
| | 54.1 | 3.7 | 4.0 | 10.9 | 14.1 | 10.4 | 0.8 | 1.9 | Girls |
| | 47.4 | 3.2 | 5.1 | 14.9 | 15.4 | 10.1 | 0.8 | 3.0 | Boys + Girls |

Table 82 contd.

Retarded Group.

| | Stable | Resistant Active | Resistant Passive | Unstable | Anxious | Inhibited | Delinquent | Neurotic | |
|---|---|---|---|---|---|---|---|---|---|
| RH.RE | 18.7 | 6.8 | 8.9 | 32.1 | 13.1 | 11.0 | 3.9 | 5.4 | Boys |
| | 24.8 | 1.5 | 10.9 | 24.3 | 13.9 | 15.3 | 11.4 | 13.4 | Girls |
| LH.LE | 17.2 | 17.2 | 14.1 | 23.4 | 14.1 | 7.8 | - | 6.2 | Boys |
| | 15.2 | 4.3 | 8.7 | 29.1 | 17.4 | 6.5 | 6.5 | 2.2 | Girls |
| RH.LE | 18.7 | 8.3 | 13.7 | 26.0 | 14.7 | 8.3 | 4.3 | 6.0 | Boys |
| | 27.4 | 3.8 | 10.8 | 26.1 | 12.1 | 12.1 | 1.9 | 5.7 | Girls |
| LH.RE | 16.1 | 13.1 | 12.5 | 32.1 | 13.7 | 7.7 | 1.2 | 3.6 | Boys |
| | 20.2 | 8.3 | 10.7 | 32.1 | 16.7 | 7.1 | - | 4.8 | Girls |
| TOTAL | 18.5 | 9.3 | 11.6 | 29.3 | 13.6 | 9.2 | 3.4 | 5.2 | Boys |
| | 24.4 | 3.5 | 10.2 | 27.3 | 14.3 | 12.4 | 3.1 | 4.7 | Girls |
| | 20.6 | 7.2 | 11.1 | 28.6 | 13.8 | 10.3 | 3.3 | 5.1 | Boys + Girls |

The groups were then analysed with reference to the 'handedness' of the children, to find if any difference existed in association with temperamental characteristics. Were righthanded children different in any way from lefthanded by reason of temperament or vice versa? Further did righthanded boys when compared with righthanded girls differ temperamentally or did trends indicate a difference with lefthanders, boys and girls.

Thus percentages were calculated of righthanded (RH) and lefthanded (LH) children with frequencies of temperamental ratings. This was done for boys and girls separately.

Table 83 presents the data.

## Table 83.

### Groups analysed re Hand - Boys and Girls.

| | Stable | Resistant Active | Resistant Passive | Unstable | Anxious | Inhibited | Delinquent | Neurotic | |
|---|---|---|---|---|---|---|---|---|---|
| **Normal Group.** | | | | | | | | | |
| RH. | 66.3 | 0.6 | 4.1 | 9.3 | 13.3 | 10.5 | 0.6 | 1.2 | Boys |
| LH. | 65.8 | 4.1 | 4.1 | 13.7 | 9.6 | 2.7 | - | - | Boys |
| RH. | 63.2 | 2.8 | 2.8 | 11.1 | 15.3 | 4.2 | - | 0.6 | Girls |
| LH. | 83.3 | - | 2.4 | 7.1 | 4.8 | - | 2.4 | - | Girls |
| **Twin Group.** | | | | | | | | | |
| RH. | 45.0 | 2.0 | 6.8 | 17.3 | 16.5 | 8.4 | 1.2 | 2.8 | Boys |
| LH. | 27.4 | 4.2 | 5.3 | 24.2 | 16.8 | 13.7 | - | 8.4 | Boys |
| RH. | 51.9 | 3.4 | 4.5 | 12.4 | 12.4 | 12.0 | 1.1 | 2.3 | Girls |
| LH. | 57.7 | 4.8 | 2.9 | 7.7 | 19.2 | 6.7 | - | 1.0 | Girls |
| **Retarded Group.** | | | | | | | | | |
| RH. | 18.7 | 7.5 | 11.2 | 29.2 | 13.8 | 9.7 | 4.1 | 5.7 | Boys |
| LH. | 16.4 | 14.2 | 12.9 | 29.7 | 13.8 | 7.8 | 0.9 | 4.3 | Boys |
| RH. | 25.9 | 2.5 | 10.9 | 25.1 | 13.1 | 13.9 | 3.6 | 5.0 | Girls |
| LH. | 18.5 | 6.9 | 10.0 | 34.6 | 16.9 | 6.9 | 2.3 | 3.8 | Girls |
| **Total Group.** | | | | | | | | | |
| RH. | 31.7 | 5.1 | 9.0 | 23.2 | 14.4 | 9.6 | 2.8 | 4.3 | Boys |
| LH. | 28.0 | 10.0 | 37.5 | 25.5 | 13.8 | 7.2 | 0.5 | 4.5 | Boys |
| RH. | 41.9 | 2.9 | 7.2 | 25.2 | 13.3 | 11.4 | 2.1 | 3.3 | Girls |
| LH. | 43.1 | 5.1 | 6.2 | 20.3 | 15.9 | 5.8 | 1.4 | 2.2 | Girls |

A similar analysis was made with reference to the 'eyedness' of the groups with temperamental rating. It was of interest to find if righteyed children showed similar or dissimilar trends in temperamental characteristics to lefteyed children. Likewise the incidence, of characteristics in right and lefteyed boys and girls, was studied from the data. Accordingly the rating percentages were calculated for the righteyed (RE) and for the lefteyed (LE). This was done for boys and girls separately.

Table 84 presents the data.

Table 84.

Groups analysed re Eye - Boys and Girls.

Normal Group.

| | Stable | Resistant Active | Resistant Passive | Unstable | Anxious | Inhibited | Delinquent | Neurotic | |
|---|---|---|---|---|---|---|---|---|---|
| RE. | 65.8 | 2.0 | 3.3 | 12.5 | 9.9 | 5.9 | - | 0.7 | Boys |
| LE. | 58.4 | 1.0 | 5.9 | 6.9 | 14.9 | 10.9 | 1.0 | 1.0 | Boys |
| RE. | 68.3 | 3.6 | 0.7 | 8.6 | 10.8 | 5.8 | 0.7 | 1.4 | Girls |
| LE. | 57.4 | - | 7.4 | 14.8 | 20.4 | - | - | - | Girls |

Twin Group.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| RE. | 41.9 | 1.8 | 5.9 | 18.9 | 18.0 | 8.1 | 0.9 | 4.5 | Boys |
| LE. | 37.5 | 3.9 | 7.0 | 19.5 | 14.8 | 12.5 | 0.8 | 3.9 | Boys |
| RE. | 51.6 | 3.7 | 5.7 | 12.2 | 13.4 | 10.6 | 0.8 | 2.0 | Girls |
| LE. | 58.9 | 3.9 | 0.8 | 8.5 | 15.5 | 10.1 | 0.8 | 1.6 | Girls |

Retarded Group.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| RE. | 18.7 | 9.1 | 10.0 | 32.0 | 12.9 | 9.8 | 2.9 | 4.6 | Boys |
| LE. | 18.2 | 9.6 | 13.6 | 25.8 | 14.4 | 8.3 | 4.0 | 6.1 | Boys |
| RE. | 23.6 | 3.4 | 10.5 | 26.3 | 15.2 | 13.2 | 3.9 | 4.4 | Girls |
| LE. | 25.4 | 3.8 | 9.9 | 28.6 | 13.1 | 11.3 | 2.8 | 5.2 | Girls |

Total Group.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| RE. | 32.5 | 6.0 | 7.8 | 25.4 | 13.7 | 8.7 | 1.9 | 3.9 | Boys |
| LE. | 28.6 | 7.0 | 11.0 | 21.4 | 14.6 | 9.6 | 2.9 | 4.8 | Boys |
| RE. | 42.9 | 3.5 | 6.8 | 17.6 | 13.7 | 10.7 | 1.9 | 2.9 | Girls |
| LE. | 40.7 | 3.3 | 6.6 | 20.2 | 14.9 | 9.3 | 1.8 | 3.3 | Girls |

Finally the numbers of pure dextral and pure sinistral children were combined and the total considered as a 'pure' group or a group showing coincidence of hand and eye. Temperamental ratings were calculated in percentages for this group.

Likewise the crosslaterals or cases of mixed hand and eye were combined and regarded as a 'cross' group and percentages of temperamental ratings found. In this way the trends of ratings could be seen for children who showed coincidence in hand and eye and those who were mixed and differences between the two types recognised.

These calculations were made for each of the groups, Twin, Normal and Retarded, and for boys and girls separately.

Table 85 presents the data.

## Table 85.

## Temperamental Ratings - Percentages of Groups - Pure with Cross Category.

### Normal Group.

| | Stable | Resistant Active | Resistant Passive | Unstable | Anxious | Inhibited | Delinquent | Neurotic | |
|---|---|---|---|---|---|---|---|---|---|
| Pure | 70.1 | 0.0 | 0.8 | 8.7 | 14.2 | 5.5 | 0.0 | 0.8 | Boys |
| Cross | 53.4 | 3.4 | 7.6 | 12.7 | 10.2 | 11.0 | 0.8 | 0.8 | |
| | 62.0 | 1.6 | 4.1 | 10.6 | 12.2 | 8.2 | 0.4 | 0.8 | |
| Pure | 70.4 | 3.7 | 0.0 | 7.4 | 12.0 | 5.6 | 0.0 | 0.9 | Girls |
| Cross | 64.1 | 0.0 | 6.4 | 14.1 | 14.1 | 0.0 | 1.3 | 0.0 | |
| | 67.7 | 2.2 | 2.7 | 10.2 | 12.9 | 3.2 | 0.5 | 0.5 | |

### Twin Group.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Pure | 39.8 | 2.0 | 7.1 | 20.4 | 18.9 | 6.6 | 1.0 | 4.1 | Boys |
| Cross | 40.5 | 3.4 | 5.4 | 17.6 | 13.5 | 14.2 | 0.7 | 4.7 | |
| | 40.1 | 2.6 | 6.4 | 19.2 | 16.6 | 9.9 | 0.9 | 4.4 | |
| Pure | 51.1 | 1.8 | 5.0 | 11.9 | 15.1 | 12.3 | 0.9 | 1.8 | Girls |
| Cross | 57.0 | 6.6 | 2.6 | 9.9 | 13.2 | 7.9 | 0.7 | 2.0 | |
| | 53.5 | 3.8 | 5.1 | 11.1 | 14.3 | 10.5 | 0.8 | 1.9 | |

### Retarded Group.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Pure | 18.5 | 8.5 | 9.8 | 30.8 | 13.2 | 10.5 | 3.2 | 5.5 | Boys |
| Cross | 17.7 | 10.0 | 13.2 | 28.2 | 14.3 | 8.1 | 3.2 | 5.1 | |
| | 18.1 | 9.3 | 11.6 | 29.4 | 13.8 | 9.2 | 3.2 | 5.3 | |
| Pure | 23.0 | 2.0 | 10.5 | 27.0 | 14.5 | 13.7 | 5.2 | 4.0 | Girls |
| Cross | 24.9 | 5.4 | 10.8 | 28.2 | 13.7 | 10.4 | 1.2 | 5.4 | |
| | 23.9 | 3.7 | 10.6 | 27.6 | 14.1 | 12.1 | 3.3 | 4.7 | |

### Total Group.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Pure | 53.3 | 5.3 | 7.5 | 24.1 | 14.9 | 8.6 | 2.1 | 4.3 | Boys |
| Cross | 28.1 | 7.6 | 10.8 | 23.6 | 13.5 | 9.8 | 2.3 | 4.4 | |
| | 30.7 | 6.5 | 9.1 | 23.8 | 14.2 | 9.2 | 2.2 | 4.3 | |
| Pure | 42.6 | 2.3 | 6.4 | 17.6 | 14.3 | 11.7 | 2.6 | 2.6 | Girls |
| Cross | 41.7 | 4.9 | 7.4 | 20.0 | 13.6 | 7.9 | 1.1 | 3.4 | |
| | 42.2 | 3.4 | 6.9 | 18.7 | 14.0 | 10.0 | 1.9 | 3.0 | |

$X^2$ values for the temperamental ratings of these children were obtained. The frequency figures of the children falling into the various hand-eye categories and temperamental ratings were analysed to show:

a) if there was any relation between handedness and temperamental rating.

b) if there was any sex difference in the temperamental ratings for the various categories of children.

c) a comparison of the children of different groups with one another, e.g. taking the normal children with retarded, these were compared, boys with boys and girls with girls, for the numbers in each temperamental rating and each hand eye category, to see if there was any difference in the rating between the groups.

(A)

Table 86 presents the $X^2$ values for relation between handedness, eyedness and temperamental rating.

Table 86.

a) Relation between handedness, eyedness and temperamental rating.

| Normal | | Twins | | Retarded | | Total | |
|---|---|---|---|---|---|---|---|
| Boys | Girls | Boys | Girls | Boys | Girls | Boys | Girls |
| Handedness | | | | | | | |
| 10.691 | 11.891 | 16.613 x | 9.118 | 15.992 x | 16.137 x | 20.673 xx | 12.549 |
| Eyedness | | | | | | | |
| 8.465 x | 17.726 | 4.160 | 7.383 | 8.284 | 1.491 | 11.576 | 2.111 |
| Pure/Cross | | | | | | | |
| 19.158 xx | 18.652 xx | 7.873 | 9.460 | 4.924 | 11.687 | 12.086 | 14.026 |

These figures show that in the Normal Group there appears to be some relation between pure-cross category and temperamental rating. The $X^2$ values of 19.158 for boys and 18.652 for girls both are significant at the 1% level.

This is not borne out in the other groups.

In the Normal group the girls show a value for eyedness of 17.726 which is significant at the 5% level. Thus there appears to be relationship with eyedness and temperamental rating of the normal girls. This is not borne out in any of the other groups.

The Retarded Group show a relation between handedness and temperamental rating. The $X^2$ values of 15.902 for boys and 16.137 for girls being significant at the .05 level. The direction of the trend for the Retarded Group can be noted on the preceding percentage sheets.

The boy Twins for handedness likewise show a value of 16.613 significant at the .05 level. The value of 20.673 for the Total boys of temperamental rating with handedness shows a significant value at the 1% level.

The pure-cross category in the Normal group boys and girls shows a significant relationship at the .01 level with temperamental rating. A glance at the percentage table will show that in general particularly with the boys, more of the temperamental characteristics classified are observed with the crosslateral group boys and girls, than are observed with the pure dextrals or pure sinistrals.

There are more stable characteristics noted with the pure group, both with boys and girls and fewer with the crosslaterals. In the other classifications there are significant differences both for boys and girls. More of the characteristic 'resistant' active is shown by the boys in the crosslateral category than by the boys in the pure group, while with both boys and girls there are higher percentages for the crosslateral group in the 'resistant' passive characteristic. A similar trend is observable in the 'unstable' classification. In the 'anxious' classification more of it is attributable to the girls than boys in the crosslateral category compared with the pure groups. It is interesting that under the 'delinquent' heading none of the 'pure' category is noted but percentages are observed in the 'cross' group for both boys and girls with slightly higher percentage for the girls. The neurotic classification presents percentages equal for the boys in the pure crosslateral groups with no percentage among the crosslateral girls. A slightly higher percentage for boys than girls appears.

The marked difference in the percentages of the 'resistant passive' classification is interesting as more of the crosslateral group show this characteristic and more boys than girls. The 'resistant active' classification shows this tendency again, for boys only. The suggestion may be that changing the hand does create an element of

resistance in the individual particularly with boys who, by innate tendency may wish to use the native handedness. It would appear also that these crosslateral types in the Normal Group do tend to show more general instability than the children with definite dominance.

In eyedness in the normal girls group, more stability characteristics show up with the righteyed girls than with the lefteyed girls. There is much more anxiety present with the lefteyed group of girls than with the righteyed. Likewise more characteristics of 'resistant passiveness' show up with the lefteyed girls than righteyed. These indications are significant for this group of girls.

Among the Retarded Group a significant relationship exists between the handedness of this group and temperamental rating. The percentage figures for stability are much higher with the righthanded boys + girls than with the lefthanded boys + girls. The characteristics for the 'resistant active' classification are very interesting as approximately 10% of this characteristic is attributed to the righthanded children while 21.1% or twice the former percentage is attributed to the lefthanders.

This is interesting in that it may be a strong indication of the amount of pressure to which these children may have been subjected and the attitudes adopted to failure to use the righthand. Likewise with the resistant passive group, a higher percentage of this characteristic is attributed to the lefthanded boys than to righthanded

boys while these children also show more anxiety than the righthanders when percentages for boys and girls are considered.

Among the Twin boys a significant relationship exists with handedness and temperamental rating. A much higher percentage of stability is present with the righthanded boy twins than with the left with consequently more instability among the lefthanders. A higher percentage shows with the lefthanders for the resistant active characteristic, for the inhibited rating, and neurotic rating, with more anxiety. The girl twins likewise show higher percentages for the lefthanded on some of these characteristics but no significance was found for them.

In considering the handedness of the Total Boys in the Twin, Normal and Retarded Groups a significant relationship was established between their handedness and temperamental rating. For all the boys more stability is present with the righthanders than with the lefthanders. Much more resistance is observed with the lefthanders than with the right. A slightly higher percentage of neurotic tendencies is also seen with the lefthanded boys.

(B)

Sex Difference.

The frequency figures of the three groups, Normal, Twins and Retarded were examined to find if there was any sex difference in the temperamental ratings for the

various categories.

Table 87 presents the data.

Table 87.

$X^2$ values -

| | Normal | Twins | Retarded |
|---|---|---|---|
| RH.RE | 5.327 | 8.780 | 15.335[x] |
| RH.LE | .723 | 26.191[xxx] | 12.052 |
| LH.RE | 11.941 | 6.959 | 11.119 |
| LH.LE | 8.151 | 13.179 | 3.374 |
| Total | 4.401 | 22.583[xx] | 25.112[xxx] |

The values for the Total Twin Group - 22.583 (significant at the 1% level) and the values for the Total Retarded Group (significant at the .1% level) are remarkable when all the children are grouped together.

This would suggest that in retarded children and twins there is a difference in temperamental rating of boys and girls (see percentage sheet, Table 82)

The crosslateral Twin Group for RH.LE is also highly significant at the .1% level.

The RHRE group in the Retarded Group is also significant at the 5% level; thus there appears to be a definite difference with these categories between the boys and girls.

A glance at the total percentages for the Twin and Retarded Group in Table 82 will make these differences clear. The difference in the Twin Group between boy and girl twins is significant at the .01 level. Thus in

relating this significance to the percentage frequencies one can observe that more stability is present with this group of girl twins than boy twins with consequently more instability among the boy twins. There is likewise more frequency of the resistant active characteristic among the girl twins but more of the resistant passive characteristic among the boy twins. A combined percentage suggests more 'resistance' among the boy twins. A higher percentage of anxiety seems to be present with the boy twins compared to girl twins with a higher percentage of the neurotic tendency among the boy twins with a slightly higher tendency to delinquency among the boy twins again. There appears a higher percentage of inhibition among the girl twins as compared with the boy twins. The crosslateral group i.e. RHLE within this Twin group is also highly significant at the .1% level. The trend tends to follow the main trend of the twin group for boy and girl twins, with the exception that in this crosslateral category there appears to be more inhibition among the boy crosslaterals than among the girls. The percentages for delinquency are equal for boys and girls; likewise with the neurotic characteristic, there is little difference between the crosslateral boy and crosslateral girl twins.

In observing the Retarded Group a difference between boys and girls was found at the .1% level. A glance at the percentage sheet of Table 82 will make these differences clear. In this group more stability is observed with the girls as compared with the boys with a consequential

increase in instability of the boys when compared. Higher percentages are found with the boys for both the characteristics of resistant active and resistant passive. Likewise in the delinquent and neurotic classifications higher percentages of boys again appear, compared with the girls. In the categories of 'anxious' and 'inhibited' a higher frequency for the girls is found than for the boys.

The righthanded righteyed category within this Retarded Group presents differences between boys and girls which are significant at the 5% level. The trend is similar to the main general trend for the group but the high percentage of delinquent and neurotic girls in this category as compared to the boys is interesting. It may be that the pure dextrals in this group have included a group of girls particularly delinquent and neurotic. This possibility may be exaggerated by the fact that some of the children in this Retarded group were clinic cases referred for these tendencies.

(C)

A comparison of the children of the different groups with one another in various hand-eye categories. Boys with Boys. Girls with Girls.

The three groups, Normal, Retarded and Twin were then compared with each other, under the categories of hand and eye, to ascertain if any significant differences would emerge in the groups, related to temperamental rating.

Table 88 presents the data. The Normal Group was compared with the Twin Group and then compared with the Retarded Group.

Table 88.

Normal with

| | Twins | | Retarded | |
|---|---|---|---|---|
| | Boys | Girls | Boys | Girls |
| RH.RE | 18.921$^{xx}$ | 17.440$^{x}$ | 99.805$^{xxx}$ | 66.628$^{xxx}$ |
| RH.LE | 27.302$^{xxx}$ | 2.780 | 35.244$^{xxx}$ | 21.227$^{xx}$ |
| LH.RE | 2.970 | 17.366$^{x}$ | 41.641$^{xxx}$ | 20.253$^{xx}$ |
| LH.LE | 14.904$^{x}$ | 12.214 | 27.628$^{xxx}$ | 43.097$^{xxx}$ |
| Total | 34.043$^{xxx}$ | 10.754 | 209.729$^{xxx}$ | 112.502$^{xxx}$ |

These values are with the exception of four all highly significant.

The values for the Normal with Retarded Groups Boys and Girls are all significant at the .1% level, except the RH.LE girls and the LH.RE girls which values are significant at the 1% level.

The Normal with Twin Group RH.LE boys and the total Normal with Twin Boys have values significant at the .1% level.

The pure dextral boys, i.e. RH.RE show a value significant at the 1% level while the boys LH.LE and girls RH.RE with girls LH.RE show values significant at the 5% level.

Normal with Retarded Group.

The values for the Normal Group compared with the

Retarded group are significant at the .1% level except for the two categories of crosslateral girls, i.e. RHLE and LHRE which are significant at the 1% level. There is thus undoubtedly a difference in temperamental rating between this normal group and retarded group. A glance at the percentage frequencies will reveal the differences. A much higher percentage is found in the stable classification with the normal group than with the retarded 63.9% in the boys and girls in the Normal Group compared with 20.6% in the Retarded Group. Inversely a smaller percentage is found in the unstable category with the Normal Group compared with Retarded. Much more resistance - both active and passive is seen in the dull group with a greater percentage in every case for the characteristics, Anxious, Inhibited, Delinquent and Neurotic.

It would appear thus that the Retarded Group are struggling with more adverse temperamental qualities than the Normal Group. These qualities may be more characteristic of the dull child and thrown into high relief when contrasted with a normal group.

Normal with Twin Group.

The comparison of Total Normal with Total Twin boys shows a significant difference at the .1% level. A glance at Table 82 will reveal the differences between the boys. There is more stability apparent among the Normal boys as compared with the Twin boys: 62.9% Normal boys as compared with 40.3% among the Twin boys. In every other characteristic in the

table, higher percentages among the twin boys are noticeable when compared with the normal boys. There is more resistance among the Twin boys, more instability, more anxiety, inhibition, delinquency and tendency to be neurotic than with the Normal boys.

The Crosslateral category of RHLE twin boys when compared with the normals shows a significant value at the .1% level while the pure dextral twin boys compared with normal pure dextral boys shows a value significant at the 1% level. The pure sinistral normal with twin boys is significant at the 5% level. The same general trends are observed as with the comparison of the Total boys with Total twin boys.

The girls group show two significant values. The normal pure dextrals compared with twin pure dextral girls is significant at the 5% level. The crosslateral category of LHRE twin girls with Normal girls is likewise significant at the 5% level.

With the pure dextral categories it can be seen from Table 82 more stability is characteristic of the Normal Group with a higher percentage seen for Twin girls in all the other classifications. The combined percentages for resistant active and passive reveals more general resistance among the Twin girls with more unstable, anxious, inhibited, delinquent and neurotic characteristic of the Twin girls more than the Normal girls.

In the Crosslateral comparison the same trends are observed but it is interesting that no delinquent characteristics

are seen in this category of Twin girls compared with the percentage among the Normal girls. Likewise no percentage showing neurotic tendencies is observed among the Normal girls compared with the Twin girls.

Observation of the groups as a whole shows a general trend of most stability in the Normal Group boys and girls with least in the Retarded Group. The Twin Group shows characteristics midway between these two former groups. Likewise for the resistance characteristic most is observable in the Retarded Group with least in the Normal Group followed by the Twins. It is interesting that as a group most anxiety is shown amon g the Twins with least in the Normal Group and the Retarded falling midway. In the inhibited characteristic Twins and Retarded approximate in percentage with least in the Normal Group. Again the highest percentage for delinquency is found in the Retarded Group with least in the Normal. Likewise the highest percentage frequency for a 'neurotic' tendency is found with the Retarded Group, Twin following and least in the Normals.

The results show that there is undoubtedly a difference in temperamental rating between the Normal and Retarded Groups. It is also noticeable that the boy twins show significant values for the righthanded (either eyed) and total children.

This suggests that the righthanded boy twins differ in temperamental ratings from righthanded boys. Thus being a twin does have some effect on temperament.

These findings are thus in keeping with the observations

of Hildreth 1949 (43) who found a measure of resistance, stubbornness and nervous instability in children who were late in establishing dominance, or whose handedness had been partially converted.

Temperamental difficulties associated with partially converted sinistrals have been reported in previous studies as awkwardness, poor muscular co-ordination, restlessness, feelings of inferiority etc. The social aspects of handedness place a strain on the child. Interference with learned skills tends to arouse emotional resistance and to produce nervous symptoms.

Burt (11) likewise noted a higher incidence of lefthandedness among children temperamentally neurotic. Lefthandedness he found to be commoner among resistant children or those who are not submissive.

The suggestion is therefore that mixed dextrality or sinistrality may be connected with general neurotic tendencies. An investigation by Cuff 1930 (17) where he tested 204 children on tests of hand and eye with relation to psychopathic tendencies showed that the children who had strong unilateral sighting tendency were the ones who were more normal emotionally.

Oates 1929 (72) reported what he considered good evidence of nervous disability in 'crossed' groups as compared with 'pure' groups.

Quinan 1930 (79) noted in a survey of 693 neuropsychiatric patients that sinistral types, especially those who were RH.LE were apt to show signs of constitutional instability. He also

investigated the handedness and eyedness of reckless drivers and found that a high percentage showed crosslaterality or mixed hand and eye.

Wolfe 1941 (116) in investigating eye and hand characteristics of reading disability cases found that more important than distinctions of handedness was the fact that his retarded readers proved to be inferior in auditory functions, visual perception, and emotional adjustment.

The findings in the present analysis similarly support the fact that more instability is present where crossed hand and eye is apparent, and more resistance characterises the sinistral child rather than the dextral particularly with boys.

This significance of temperament associated with laterality may be the explanation of the poorer achievement of the boys on the educational tests, when compared with the girls. More boys than girls show crosslateral tendencies and more boys than girls tend to be resistant and unstable. Thus consistency may be more a matter of temperamental stability than manual skill. One may find a constitutional lefthandedness present in an individual. All attempts to change the sinistral expression may end in failure with associated negative attitudes and resistance arising when attempts are made to do so. On the other hand a disposition or temperamental diathesis may be inherited such that sinistral tendency appears as a quasi-neurotic

reaction. It was noted in the analysis that more neurotic tendencies were present in lefthanders in the Total Group and particularly among the boys. Thus sinistral tendency may be one aspect of a situation of more general maladjustment in the individual. The male side of the population would thus appear to be more negatively weighted than the female.

These temperamental characteristics of general instability appear strongly in the Retarded Group which is one of dull children, immature mentally and emotionally. Likewise in this group most instances of mixed hand and eye and strong sinistral tendency were present. The maladjusted individual tends to show an immature personality. Thus consistency of hand and eye may characterise the normal well integrated mature person and be a function of maturation and normality.

Deviations from normality will tend to show degrees of abnormality. Thus the Twin Group as a group constitute a biological deviation from normality and with them differences in temperament inclining to anxiety and neuroticism were likewise observed. Cases of mixed hand and eye were not so numerous among the twins but the highest percentages of sinistral tendency were observed.

If twinning tendency is inherited and if, as has been shown in the analysis, being a twin has an effect on temperament, then a 'twin-temperament', associated with instability, anxiety and neurotic trends may be an inherited factor, which is likewise accompanied by sinistral expression.

Thus instability or lack of balance in temperament may be closely paralleled by a lack of stability or inco-ordination of hand and eye. Individuals of such temperament, as has been shown by previous investigators, may tend to show greater preponderance of sinistral or mixed sinistral expression, but it is indeed difficult to determine whether the sinistrality or crosslaterality is the cause or the effect of the temperamental factor.

## Summary of Temperamental Analysis.

### Normal Group.

Groups showing coincidence of hand and eye show significantly more stability than those showing mixed hand and eye.

More 'resistance' appears with the boys compared with the girls. More stability is shown by the righteyed girls and more anxiety is present with the lefteyed girls.

Handedness is not significant for boys or girls in the Normal Group.

### Retarded Group.

Righthanded Retarded Group children show more stability than lefthanded. More resistance and anxiety is significantly present with the lefthanded boys and girls.

### Twin Group.

More stability is present with the righthanded boy twins than with the lefthanded. More resistance is present with the lefthanded boy twins.

### Total Group.

More stability is significantly present with all the righthanded boys. More resistance and neurotic tendencies are present with the lefthanded boys.

A sex difference is definitely present in the Twin and Retarded Groups. In general more stability is found in these groups for girls compared with boys. More 'resistance' is found with the boys.

Significant differences are present in a comparison of

the Normal with Retarded Group and with the Twin Group. More stability is present with the Normal Group. More 'resistance' is shown in the Retarded Group.

Likewise more stability is present in the Normal Group compared with the Twin Group and more unstable characteristics are present in the Twin Group.

Most stability is present in the Normal Group: least in the Retarded Group.

Most resistance is found in the Retarded Group: least in the Normal Group.

Most anxiety is found in the Twin Group.

Greatest tendencies to delinquency with neurotic tendencies are observed in the Retarded Group, followed by the Twin Group.

Boy Twins show significant differences in handedness compared with Total children with differences in temperamental rating.

## References.


43. Hildreth G. 1949 - The Development and Training of Hand Dominance. J. Genet. Psych. 75.

17. Cuff N.B. 1930 - The Relation of Eyedness and Handedness to Psychopathic Tendencies. J. Gen. Psych. 1930 - 37, 530 - 536.

72. Oates D.W. 1929 - Lefthandedness in relation to Speech Defects, Intelligence and Achievement. Forum of Educ. 1929 - 7.

79. Quinan C. 1930 - The Principal Sinistral Types. An Experimental Study particularly as regards their Relation to the so-called Constitutional Psychopathic States. Arch. Neur. and Psychiat. 1930 - 24, 35 - 47.

116. Wolfe L.S. 1941 - Differential Factors in specific reading disability. 1. Laterality of Function. J. Genet. Psych. 1941 - 58, 45 - 56.

88. Schonell F.J. - The Relation of Reading Disability to Handedness and certain ocular factors. Brit. J. Educ. Psych. 1940 - 10, 3.

111. Wile I.S. and Davis R. - A study of failures on the Stanford-Binet in relation to behaviour and school problems. J. Educ. Psych. 1941. 32.

11. Burt C. - 1950 - 3rd Edition. The Backward Child. New York, MacMillan.

## Section IV

### Chapter 14.

### Performance Tests.

The Total Laterality Group of 770 children from the original 1044 were given three performance tests. The tests described in an earlier section consisted of

a) Hoopla Board Test.

b) Bean Bag Throwing.

c) Peg Board Test.

These performance tests were given in an abbreviated form firstly as a trial test and then as a final test. The forms on which results were recorded are found in Appendix A, Forms 1a and 2a.

The aim of the tests was primarily observation of the preferred hand used by the child in three performances of acquired skill. By scoring results an estimation of accuracy was also found for the preferred hand and for the non-preferred hand. The difference between the hands in terms of accuracy was then apparent.

As studies of performance tests have shown that a battery of tests is always more reliable than any one test, results were scored and obtained for the three tests combined. Consistency in the tests was measured by finding

the percentage of children who made a better score with the non-preferred hand as compared with preferred hand. In the present consideration of the threefold battery, the average inconsistency found in the group was 21.4%. Thus 21.4% children scored higher with the non-preferred hand than with the preferred hand.

With the exception of the Peg Board test, which showed 10.3% inconsistency over the total groups, the individual tests showed greater percentages of inconsistency than the composite score inconsistency. The Hoopla test showed 30% of pupils who made greater scores with the non-preferred hand, while the Bean Bag throwing test showed 24% inconsistency. The Peg Board percentage of 10.3% is thus remarkably smaller than the percentages found on the other two tests. These findings agree with the investigation of Cooper and Bonney 1942 (15) who used tests similar to the above in their study of 125 elementary schoolchildren. They confirmed the fact that none of the three unimanual tests on which scores were obtained by them, was as satisfactory a measure of handedness as a combined score. They also found that most of the subjects who made a better score with the non-preferred hand were lefthanded children who did better with the right hand, due to the effect of training in right hand usage.

Previous consideration of the 'shifthandedness' of the Laterality Group revealed that approximately 25% of the children were cases trained in the righthand although

innately lefthanded. This percentage approximates closely to the amount of inconsistency as revealed in the Performance Tests.

In finding tests of reliable hand indication, where dominance is concerned, investigators have stated different preferences. Dart 1938 (21) found that pointing and reaching tests were most reliable. Turner 1939 (101) found throwing tests to be best. He found in a study of adolescents that 3.5% did better with the non-preferred hand. Haefner 1929 (36) thought that the throwing activity of an individual revealed the dominant handedness correctly in 9 our of 10 cases for both left and right handed subjects.

These investigators did not consider the case of shifthandedness where the individual had been changed over. The high percentages of inconsistency found for these two throwing tests i.e. hoopla and bean bag, may be revealing in this respect. Apart from test conditions and chance factors, a large number of children did well with the non-preferred hand. Might this be partly the result of innate handedness emerging if the claims of Turner and Haefner are justified that throwing reveals true handedness? Likewise with these tests 'body set' is introduced in that a child tended to turn the body to one or other side when throwing. This would involve a wider aspect of laterality concerned with 'sidedness'. If the high score with the non-preferred hand is due to a shift or change of hand covering innate handedness the true 'sidedness' of the individual cannot

so easily be changed. This extra weighting towards innate laterality may also have affected the accuracy in throwing, thereby resulting in a high score for a non-preferred hand, but which from a laterality standpoint, was actually the 'true' hand of the individual.

The Peg Board Test showed the smallest percentage inconsistency with each of the groups and the smallest total inconsistency. This test was perhaps less subject to chance errors as in each case the board was placed on a table the height of which varied little from situation to situation. The child worked in a smaller uniform area and moreover 'sidedness' was not introduced to the same extent as in the throwing tests. The test involved manipulatory activity of the fingers rather than larger muscular movement as in throwing; hence the effect of training could tend to be more pronounced.

(A)

On the Performance Tests, i.e. Hoopla Board, Bean Bag Throwing and Peg Board Manipulation, total composite scores were found for each group and for boys and girls separately. The percentage of the possible score was found for each group and the average score per try.

These tables can be found in the Appendix B, Tables 22 and 23.

A general comparison of the groups for boys and girls

reveals certain trends.

Twin Group

The difference between the preferred and non-preferred hand is greater for the boy twins than girl twins on both trial and final testing. Likewise the percentage score obtained by the girls is smaller than that obtained by the boys. This would seem to indicate that the girl twins are not so accurate on the performance tests as are the boy twins. Stronger unimanual preference appears with the boys. In all the twins the preferred hand shows the higher score and is thus more accurate.

Retarded Group.

The same trend is seen with the Retarded Group, as was observed in the Twin Group, in that the girls show a poorer percentage score than the boys with preferred and non-preferred hand. The boys are therefore more accurate than the girls. The differences between the hands on the Trial testings and on the Final testings are approximately the same for both boys and girls. Thus no strong unimanual preference shows with this group. With both boys and girls the non-preferred hand shows the poorer score.

The percentage scores made by the Retarded Group are in every case both for boys and girls poorer than for the Twin Group. The accuracy of the Retarded Group is thus poorer than that of the Twin Group.

Normal Group.

In the Normal Group the girls show lower percentage scores than the boys, again the same trend as seen with the Twin and Retarded Groups, although the percentage score for the preferred hand on Trial test for boys and girls is similar. The difference between the preferred and non-preferred hand with the Normal Group does not follow the pattern of the Twin or Retarded Group, as the differences are greater with the girls both on Trial and Final test. Thus these Normal Group girls appear to show a stronger unimanual preference than do the boys.

Girls.

The differences between the hands on both trial and final tests is greatest for the girls of the Normal Group when compared with the Twin and Retarded Group girls. The Retarded Group girls show the least score difference between their preferred and non-preferred hands. The Twin girl group show differences nearer to the Normal girls group than to the Retarded girls.

These differences suggest that the Normal Group girls may be showing the most definite dominance in handedness while the Retarded Group girls may be showing least. Previous analysis of the Laterality characteristics of the groups showed a higher percentage of girls than boys to be coincident in hand and eye in both Twin and Normal Groups. There is greater occurrence of shifthandedness among the Retarded girls or indefinite dominance. The highest percentage of crosslaterality was found with the Retarded

Group when laterality characteristics were considered. The Twin girls however, reveal most accuracy in the final testings by reason of their highest scores. The highest percentage of coincidence of hand and eye appeared in the Twin Group girls on earlier consideration of laterality characteristics.

Boys.

These trends do not apply to the boys. The difference between the hands is greatest with the Twin boys and least with the Retarded boys. Again this may indicate that the duller boys of the Retarded Group are characterised by shifthand cases in that their non-preferred hand may be their true hand. It may be also that there is more dominance with the Twin boys group. An earlier investigation of their laterality characteristics revealed a high percentage of crosslaterality with the Retarded Group while a high percentage of pure dextrality and pure sinistrality was observed with the Twin Group. The Normal boys show differences similar to the Retarded Group on trial testing but midway between the Retarded and Twin Groups on the final testings.

The accuracy of the Boy twins is higher than for the Retarded boys and closely approximates to the accuracy on test score of the Normal boys. The trends bear out the inference that the dull child is inferior to the Normal in tests of accuracy.

The perfomance Tests were then considered individually for each of the three groups, Twins, Retarded and Normals

and for boys and girls separately.

(B)

Hoopla Test.

The Hoopla Test was given first as a trial test on which three throws were made, and then as a final test on which eight throws were made. The maximum possible score on the trial test scoring 15 each time was thus 45. The maximum possible score on the final test scoring 15 each time was 120 for one individual.

The total scores made by each group with preferred hand (P.H.) and non-preferred hand (N.P.H.) on the trial and final tests were calculated. This total score as a percentage of the total possible score for each group was then calculated and finally the average score per try was found.

Tables 24 and 25 in Appendix B present the data separately for girls and for boys.

With the Hoopla Test the trends show higher average scores per try for the boys than for the girls with the preferred hand showing the higher score compared with non-preferred. On this test the greatest inconsistency was shown where the highest number of children did better with the non-preferred hand. Practice effect may be operating but the nature of the test involved aiming

with throwing. Thus the effect of the dominant eye and visual acuity together with sidedness of the body may be involved to complicate the problem. The boys show greater accuracy than the girls but by their sports boys tend to be trained more in throwing than do girls.

In comparing the groups on the Hoopla Test the percentage score of the total possible score is for each group very low, in every case, less than 25%. The Twin and Normal Group girls show similar percentage scores both being higher than the percentage score of the Retarded Group. With boys the same trend can be seen.

This test would appear to have been difficult for the groups in that the combination of skill and accuracy may have been too great for their powers of co-ordination of hand and eye.

By the nature of its administration the Hoopla Test inevitably was subject to many chance errors, and these may be depressing the total accuracy picture.

(C)

Bean Bag Test.

The Bean Bag Test was given in two forms - a trial test and final. In the trial test 3 tries were given with each hand while on the final test 10 throws were made with each hand.

The total possible individual score on the trial

test scoring 10 each throw, was 30. The total possible individual score on the final test scoring 10 each throw was 100.

Tables 26 and 27, Appendix B, present the scores and percentages of the total score with the average score per try for each of the 3 groups, firstly for all the girls and then for all the boys.

In comparing boys with girls on the Bean Bag test the trends are similar to the Hoopla test.

The total average score for the boys is in every case higher than for the girls. This is true for each of the groups, Twin, Retarded and Normal.

In considering girls alone, the Normal Group show the highest percentage score for preferred hand on the trial test with the Retarded girls showing highest percentage for the non-preferred hand. The girls in the Normal Group show the greatest score differences between the hands both for trial and final testing. The Retarded girls show least. These tendencies may be related to the high percentage of mixed dominance found in the Retarded Group compared with Normal.

In considering boys alone similarity of performance is evident among the groups. The greatest score difference between the hands on trial and final testing lies with the Twin Group of boys. Strong differentiation in the Twin Group is associated with the high percentage of coincidence of hand and eye found formerly with the twins as they showed the least amount of crosslaterality.

All groups are alike in that the percentage total score is low; hence like the Hoopla Test chance factors may be operating to reduce the accuracy. This test likewise involved two activities - aiming and throwing and the combination may have proved of some difficulty.

(D)

Peg Board Test.

In the Peg Board Test a trial period of half a minute was given and the number of pegs in the board taken as the score followed by a final test when a full minute was given.

The total possible score for one individual on the trial test was 64 as there were 64 holes in the board. The total possible score for the final test was 64 also. Tables 28 and 29 Appendix B, present the total scores, percentage scores and average score per try for boys and girls separately.

In comparing the total average scores on the Peg Board test for boys and girls, little difference is seen. A very slight difference in favour of the girls on preferred hand can be noted but it is not great. Thus the boys and girls appear to be equally good at inserting pegs in the board. The score for one minute is twice that for the half minute.

In 1942 J.T. Rusmore found a significant tendency to poorer performance for men as compared with women when he

applied 100 pegs in a board to college students. He thinks that in any similar test a sex difference will be observed. This is not observed here but in relation to the higher scores obtained by boys on the other two performance tests, one can observe that the boys have not maintained their lead on this test.

In considering the girls alone the average scores appear similar but the percentage of total score to possible score for the groups differs. The Twin girls show the highest percentages for both trial and final testing while the Retarded Group girls show the least. The Twin girls as a group would thus appear to show most accuracy with the Retarded girls showing least.

With the boys the average scores likewise show similarity from group to group. The Normal Group boys however show the highest percentage total score followed closely by the Twins. The differences between the hands show least group difference for the Retarded Group girls on both trial and final testing and least for the Retarded Group boys on trial testing with Twin and Retarded boys showing similar differences on the final testings.

The percentage total scores are not high throughout the groups. The Peg Board test involved a measurement of speed together with accuracy. Mixed hand cases may be influencing the low score, as it was observed that several children, particularly in the Retarded Group, picked up pegs with one hand - transferred them to the

other hand before inserting them - usually the left when inserting them with the right hand.

In these performance tests hand skill was observed but it is evident that the spatial orientation of the children in their estimation of distances in throwing the bags or rings may be influencing the ultimate result. Likewise perceptual discriminations are involved. Subjective observation confirmed that some children overestimated the position of the bean bag box and threw beyond it, while others tended to throw to the right or left of the target. It is difficult to estimate the influence of the eye, but the low scores might suggest that apart from chance, accurate aiming and precision in direction was being adversely affected by visual factors.

## Summary of Findings for the Performance Tests.

The individual performance tests showed greater inconsistency, with the exception of the Peg-board, than the percentage found for a combined score. This inconsistency was noted in each group, Twins, Retarded and Normals.

The girls generally show poorer scores than the boys.

The preferred hand shows the higher score in every case.

The difference between the hands tends to be greater for boys than for girls. Boys thus tend to show stronger unimanual preference.

There is least difference between the hands of the Retarded Group. Cross-laterality or cases of shifted hand may be affecting the trend.

Scores for the Twin and Normal Groups tend to be higher than for the Retarded Group; thus more accuracy is present with the Twins and Normals. The groups are similar in that all show low group-percentage scores.

## References.


15. W.E. Cooper and M.E. Bonney - The Validity and Reliability of the Van Riper Critical Angle Board in Diagnosing. Handedness - Journal of App. Psychology. 1942 - 26.

21. Dart C.E. - Hand, Eye and Foot preferences of 200 mentally subnormal subjects compared with that of normal intelligence or above. Journal of Juvenile Research. April 1938 - 22, 119 - 122.

101. Turner E. - Studies in Eye, Hand and Foot preferences of emotionally unstable adolescents compared with stable adolescents. Journal of Juvenile Research. April 1939 - XXII No. 2.

36. Haefner R. - The Educational Significance of Lefthandedness. Teachers College Contributions to Education. 1929 No. 360.

## Chapter 15.

## The Van Riper Test.

The Van Riper Test consisted of 3 parts.

a) Visual

b) Script

c) Kinaesthetic.

The visual part involved the drawing of a pattern of a four looped figure (see Appendix A, Illustration 6a) as used by Cooper and Bonney 1942 (15).

This was placed at an angle of $30^{\circ}$ before the child and drawn by both hands at the same time on the writing boards of the Van Riper. These boards were converged through the angles $0^{\circ}$ to $90^{\circ}$. The angle at which mirroring occurred was noted and the degree recorded together with the hand which mirrored.

The Script pattern was the auditory stimulus of the word 'cat' which was written simultaneously by both hands on both boards. Again the hand mirroring was noted and the degree recorded.

The Kinaesthetic test consisted of a pattern resembling the body of a bear which was grooved in a metal slab. This was traced by a doublehandled stylus which the child held when blindfold. He was timed while learning the figure. When a knowledge of the shape of the pattern had been gained the pattern was reproduced by both hands on the

writing boards of the Van Riper. These were again converged through the angles from $0^{o}$ to $90^{o}$. The hand mirroring the pattern was noted and the degree recorded.

Thus the degree of angle at which mirroring occurred was recorded for each child and a composite average score was obtained, by adding the three separate degrees and averaging.

It was found that the children varied greatly in the angle at which they mirrored and also in the type of mirroring presented. Some children mirrored on all three tests with the one hand. They were regarded as being consistent mirrorers and strongly dominant. Other children mirrored on, e.g. the visual and kinaesthetic test but not perhaps on the script test, thus mirroring on two tests.

Some children mirrored on only one test, and not on the other two tests while a few showed no mirroring.

All these children have been classed as consistent mirrorers in that mirroring was definite either on the three tests or on two or one test.

A further distinction was made by children who mirrored part of a pattern, for example, in the visual test. Some mirrored the top half of the pattern with the right hand and the bottom part of the pattern with the left hand or vice versa. Some children seemed to mirror in a horizontal plane as well as vertical.

Further a group of children tended to mirror with the right hand and then to draw the correct pattern with the

same hand followed by the mirrored pattern at the next attempt. These children alternated between normal and mirrored pattern either with one or both hands. These groups were termed 'partial' and 'inconsistent' mirrorers. They were found to be so on the three tests, on two tests and on one test, i.e. they might show no mirroring on two tests and then perform erratically on the third.

The composite average degree of mirroring was calculated for all the girls and all the boys of the Total Laterality Group. Likewise for the respective subgroups of Normal, Twin and Retarded. These calculations were made for each category of hand and eye in the subgroups. (See Tables 30 - 35 in Appendix B).

The following table 89 presents the summarised data for girls alone and boys alone in numbers and percentages for mirroring on the tests both for 'consistent mirrorers' and 'partial and inconsistent mirrorers'.

Table 89.

Girls N = 341

Consistent Mirrorers.

| | On 3 Tests | On 2 Tests | On 1 Test | No Mirror. on Tests. |
|---|---|---|---|---|
| Number Mirr. | 209 | 51 | 28 | 4 |
| % | 61.3 | 14.9 | 8.2 | 1.2 |
| Av. deg. mirr. | 45.4° | 60.9° | 70.7° | - |

Partial and Inconsistent Mirrorers.

| | | | | |
|---|---|---|---|---|
| Number Mirr. | 31 | 15 | 3 | 0 |
| % | 9.1 | 4.4 | 0.9 | - |
| Av. deg. mirr. | 49.6° | 70° | 56.6° | - |

Boys N = 429

Consistent Mirrorers.

| | On 3 Tests | On 2 Tests | On 1 Test | No Mirror. on Tests. |
|---|---|---|---|---|
| Number Mirr. | 298 | 64 | 20 | 5 |
| % | 69.5 | 14.91 | 4.7 | 1.2 |
| Av. deg. mirr. | 46.2° | 57.2° | 61° | - |

Partial and Inconsistent Mirrorers.

| | | | | |
|---|---|---|---|---|
| Number Mirr. | 32 | 8 | 2 | 0 |
| % | 7.45 | 1.9 | 0.5 | - |
| Av. deg. mirr. | 49.3° | 52.5° | 60° | - |

More than 75% of the girls group and more than 75% of the boys group showed 'consistent' mirroring tendencies. Thus in our total group a high percentage show definite dominance on the tests. For both boys and girls, the

angle of mirror tended to increase as the tendency to mirror decreased. The angle for 3 tests is smaller than the angle on 2 tests which again is less than the angle on 1 test. (Numbers also affect the result). A similar trend can be observed in the 'partial and inconsistent' mirrorers group. This is difficult to explain but may be associated with the age of some of the children. An analysis with age tended to support the theory that mirroring tendency decreased as the child grew older and thus established more control. It may very well be however that slower mirroring is associated with 'difficulty' and a learning factor operates to slow down performance as a few of the children who showed 'no mirroring' tendencies were unable to co-ordinate both hands at the same time and hence could not draw the patterns.

In comparing the definite mirrorers, boys with girls on the Van Riper, a greater percentage of the boys group compared with the girls group show mirroring on the 3 tests with similar average degrees of mirroring slightly greater with boys. Equal percentages of boys and girls mirror on 2 tests with the angle slightly greater for girls while a higher percentage of girls is apparent in mirroring on 1 test. A similar percentage of 'no mirroring' appears both for boys and girls.

In comparing the 'partial and inconsistent' mirrorers, boys with girls, a higher percentage of girls as compared with boys, show mirroring on 3 tests, the angle of mirroring

being similar for both boys and girls at 49°. A greater percentage of girls is also observed to mirror on 2 tests, the angle being greater for the girls. On 1 test .9% girls and .5% boys show mirroring although the numbers in this category are small. A greater percentage of girls show partial and inconsistent mirroring than do boys. This may be partly due to the more definite training in unimanual handedness which boys tend to receive compared with girls. More dominant handedness may thus be established in boys compared with girls, as the girls were also poorer on the Performance Tests. Thus strength of dominance may be illustrated in this 'inconsistent' mirroring among the girls compared with boys.

Cooper and Bonney found that the critical angle at which mirroring occurs on the Van Riper test varied from subject to subject according to the degree of right or lefthandedness. The average critical angle found for their lefthanded subjects approximated to 43° while that for righthanded subjects was 50°. In this study the average critical angle found for 209 girls who mirrored on 3 tests was 45° while the average critical angle for 298 boys who mirrored on 3 tests was 46°. These angles range between those found for right and lefthanded subjects in Cooper and Bonney's investigation.

Combining the consistent and inconsistent groups and comparing righthanded girls with righthanded boys, on 3 tests, the average composite degree of mirroring

approximated to 45° for girls and 47° for boys. Comparing lefthanded girls with lefthanded boys, the average degree of mirroring for girls is 51° and 54° for boys. Thus the angle of mirroring for boys is slightly greater on three tests than for the girls while the lefthanded children show greater degree of mirroring for both boys and girls compared with righthanded. The slower tendency of lefthanded children to mirror when compared with righthanded is interesting. Many children were cases of shifted hand, trained in righthanded methods. It is feasible therefore to surmise that interference from righthand training may have been creating a situation of conflict which operated to slow down a tendency of the natural lefthand to mirror. This was seen in observation of the performance of some children who showed one half of a pattern mirrored and the other half normally presented.

In the three groups of Normal, Retarded and Twin children, there appears to be no great difference in the composite average degrees of mirroring either for boys or girls.

The aspects of the Van Riper test were then considered singly. In considering the mirroring tendencies on the Visual, Script and Kinaesthetic tests, the average degree of mirroring was found (1) for all consistent mirrorers and (2) for all those classed as partial and inconsistent, (3) lastly those children who showed no mirroring were noted and grouped. This was done for each category of

hand and eye and for each of the subgroups, Normals, Twins and Retarded, and for boys and girls separately. These detailed tables can be found in the Appendix B Tables 36 - 44.

The findings were summarised for each group on the 3 aspects for boys and girls separately and are given in the following tables 90, 91 and 92.

Table 90.

VISUAL TEST.

Normal Group.

| | Girls N = 75 | | | Boys N = 95 | | |
|---|---|---|---|---|---|---|
| | No. | % | Av. degree mirror. | No. | % | Av. degree mirror. |
| Consistent Mirrorers | M59 | 78.6 | 49.3 | 85 | 89.4 | 51.2 |
| Partial Mirrorers | 10 | 13.3 | 55.5 | 7 | 7.3 | 58.5 |
| No mirroring | 6 | 8. | - | 3 | 3.1 | - |

Retarded Group.

| | Girls N = 110 | | | Boys N = 190 | | |
|---|---|---|---|---|---|---|
| Consistent Mirrorers | 96 | 87.2 | 47.6 | 165 | 86.8 | 51.7 |
| Partial Mirrorers | 13 | 11.8 | 51.5 | 21 | 11.0 | 60.9 |
| No Mirroring | 1 | .90 | - | 4 | 2.1 | - |

Twin Group.

| | Girls N = 156 | | | Boys N = 144. | | |
|---|---|---|---|---|---|---|
| Consistent Mirrorers | 126 | 80.7 | 56.6 | 119 | 82.6 | 55.7 |
| Partial Mirrorers | 25 | 16. | 55.5 | 18 | 12.5 | 47.2 |
| No mirroring | 5 | 3.2 | - | 7 | 4.8 | - |

Table 91

SCRIPT TEST.

Normal Group.

| | Girls N = 75 | | | Boys N = 95 | | |
|---|---|---|---|---|---|---|
| | No. | % | Av. degree mirror. | No. | % | Av. degree mirror. |
| Consistent Mirrorers | 58 | 77.3 | 52 | 78 | 82.1 | 55.7 |
| Partial Mirrorers | - | - | - | 1 | 1 | 80. |
| No mirroring | 17 | 22.6 | - | 16 | 16.8 | - |

Retarded Group.

| | Girls N = 110 | | | Boys N = 190 | | |
|---|---|---|---|---|---|---|
| Consistent Mirrorers | 92 | 83.6 | 49.4 | 174 | 91.5 | 53.3 |
| Partial Mirrorers | - | - | - | 1 | .52 | 30. |
| No mirroring | 18 | 16.3 | - | 15 | 7.8 | - |

Twin Group.

| | Girls N = 156 | | | Boys N = 144 | | |
|---|---|---|---|---|---|---|
| Consistent Mirrorers | 131 | 83.9 | 53.1 | 130 | 90.2 | 52.1 |
| Partial Mirrorers | - | - | - | - | - | - |
| No mirroring | 25 | 16. | - | 14 | 9.7 | - |

Table 92

KINAESTHETIC TEST.

Normal Group.

| | Girls N = 75 | | | | Boys N = 95 | | | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | Av. deg. Mir. | Av. Time | No. | % | Av. deg. Mir. | Time |
| Consistent Mirrorers | 58 | 77.3 | 44.1 | 161.3" | 73 | 76.8 | 44.2 | 141.6" |
| Partial Mirrorers | 3 | 4. | 56.5 | 111.6" | 1 | 1 | 40. | 85" |
| No mirroring | 14 | 18.6 | - | - | 21 | 22.1 | - | - |

Retarded Group.

| | Girls N = 110 | | | | Boys N = 190. | | | |
|---|---|---|---|---|---|---|---|---|
| Consistent Mirrorers | 93 | 84.5 | 43.7 | 170.4" | 167 | 87.8 | 40.5 | 171.4" |
| Partial Mirrorers | - | - | - | - | - | - | - | - |
| No mirroring | 17 | 15.4 | - | - | 23 | 12.1 | - | - |

Twin Group.

| | Girls N = 156 | | | | Boys N = 144 | | | |
|---|---|---|---|---|---|---|---|---|
| Consistent Mirrorers | 113 | 72.4 | 40 | 156.4" | 119 | 82.6 | 43. | 140.4" |
| Partial Mirrorers | - | - | - | - | - | - | - | - |
| No mirroring | 43 | 27.5 | - | - | 25 | 17.3 | - | - |

Each group is considered in turn in its performance on the Van Riper. The varying numbers in each group limit the validity of the comparisons but general trends are considered.

(A)

Normal Group.

Visual Aspect.

Compared with girls, the boys on the visual test show a higher angle of mirroring, both for consistent and inconsistent groups. The boys are therefore slower to mirror. It may be that the boys are slower to learn the pattern than girls. The number of lefteyed boys in the Normal Group is twice that of lefteyed girls, thus greater confusion in visual perception may be a possible contributory factor. A higher percentage of consistent mirrorers is present among the boys compared with the girls. Thus while the boys show a tendency to slowness of mirroring they show more definite dominance.

Van Riper, in his 'Quantitative Measurement of Laterality' used subjects of older age than in the present study as his subjects were University students while the present group comprised elementary schoolchildren. There were 35 RH and LH subjects with 30 Ambi cases in Van Riper's study. In the present one were 341 girls and 429 boys.

The average of the critical angles made by members of the RH group with Van Riper on a simple version of the

visual pattern was 27° with 32° on retesting. The angle for the lefthanded group was 27° with 30° on retesting. The ambidextrous individuals showed higher angles, the average being 69° and 73° on retesting while a partially righthanded group showed an average of 49°. He included a group of 30 stutterers who showed an average critical angle of 67°.

The present findings show average angles similar to Van Riper's partially righthanded group and nearer his adult ambidextrous subjects than his dextrals or sinistrals. The difference in angles may be partially explained by unequal difficulty of the patterns and the age difference of the groups. Cooper and Bonney found on the visual test an average critical angle of 49° for RH subjects and 36° for LH subjects. The present findings tend to reverse this order as the lefthanded subjects showed larger angles of mirroring than the righthanded. A factor of learning may enter as the children did not require to reproduce the visual pattern to the beat of a metronome as in the former study. The pattern may therefore have presented more difficulty to sinistral types, whether of changed hand or not, necessitating a longer period in learning with consequent effect of later mirroring. The hypothesis of a learning factor slowing down spontaneous mirroring is supported by the fact that many children drew a part of the pattern and then visibly hesitated before proceeding more slowly and carefully, despite encouragement to proceed quickly without thinking about the figure.

Script Test.

(See appendix B Table 37 for detailed calculation.)

Results in the Script test for the Normal Group were similar to those obtained for the Visual test. The boys showed a higher percentage of consistent mirroring with a higher degree of mirroring angle when compared with the girls. If consistency of mirroring indicates greater dominance then again the boys show a stronger tendency than the girls. On the other hand their strength of dominance may equally well lead to slower mirroring as greater difficulty might be experienced in using both hands simultaneously. The high percentages of both boys and girls who show no mirroring is interesting. A possible explanation may lie in the familiarity of the stimulus word. The word 'cat' was known to all the children from school books and lessons. Thus the experience of familiarity may have helped to establish control over the hands in writing it.

There was one partial mirrorer among the boys.

On the Script test Cooper and Bonney found an average critical angle for their RH subjects of 49° and for the LH subjects an average critical angle of 58°. The average critical angle found for definite mirrorers among the girls was 52° and 56° for boys. The findings thus approximate closely to those previous investigators.

Van Riper found on the Script test an average critical angle of 20° with 26° on retest for his RH group of 35, and

an average critical angle of 23° with 25° on retest, in his LH group of 35. His ambi group of 30 subjects showed an average critical angle of 65° with 67° on retest, while 30 stutterers showed an average critical angle of 45°. Again the findings of this group tend to approximate more closely to the results obtained by Van Riper for his cases where indefinite dominance appears.

## Kinaesthetic Test.

The findings of the Normal Group for the Kinaesthetic test were then considered. (See Appendix B, Table 38 for detail).

On the Kinaesthetic test approximately the same percentages of girls as of boys enter the consistent group while the average angle of mirroring is the same for both. The time taken by the girls to learn the kinaesthetic pattern is greater than for the boys.

A greater percentage of boys showed no mirroring. The partial cases were too few in number to yield valid conclusions - 1 boy with 3 girls.

The equal percentages of boys and girls on the Kinaesthetic pattern who showed stable mirroring is interesting in the suggestion it bears for kinaesthetic learning or learning by the 'muscle feel' of a pattern. The average degree of mirror is smaller also than that found for both visual and script pattern. The kinaesthetic pattern differed from the visual in that the 'eye' was excluded while the difference from the script pattern

lay in the fact that it had not been already 'taught'. The smaller angle of mirroring might indicate therefore more spontaneous mirroring in the sense that learned or acquired eye or hand habits were excluded. Boys appear to learn more quickly from kinaesthetic clues than the girls in that their learning time was shorter. This may also be indicative of mechanical skill as they appeared superior to the girls on the performance tests.

Cooper and Bonney found a large critical angle for their righthanded group 53° on the kinaesthetic pattern while their lefthanded group showed a smaller angle of 35°. The average angle found for both boys and girls in this group approximated midway between these findings. Van Riper found smaller angles of 31° and 35° for his right and lefthanded group with 52° for his partially righthanded group. The smaller angle may be indicative of a quicker learning capacity in his group as they were adult. His subjects were untimed but performed within the double beat of a metronome.

(B)

Retarded Group.

The performance tests were then individually considered for the Retarded Group in the same fashion as for the Normal Group. (Appendix B Table 39 presents the detail)

Visual Pattern.

The boys and girls of the Retarded Group show equal

percentages of consistent mirrorers but the angle of mirroring is higher for the boys. If the significantly lower achievement of the Retarded Group boys with girls is considered, a slower power of learning may be operating. Equal percentages of indefinite mirrorers are likewise seen for both boys and girls.

The angles of mirroring for both Normal and Retarded Groups were very similar approximating to 50°, the partial mirrorers among the Retarded boys showing a slightly higher angle or slower mirroring tendency. The girls of the Normal Group revealed this tendency also.

Van Riper tried his visual pattern with 10 children from a state orphanage, having I.Qs. below 80. He found that the average angle for them was 43°. The visual pattern used here, although an approved adaptation, might be more difficult than the pattern used by Van Riper in his original experiment, hence a slower rate of mirroring might result.

Script Test.

The boys of the Retarded Group on the Script test show a higher percentage of definite or consistent mirroring than do the girls. The angle of mirror is also higher for the boys. No girls show partial mirroring and only one boy while a higher percentage of girls show no mirroring tendency compared with the boys. The strength of dominance and definite unimanual tendency among boys compared to girls may be reflected in the higher percentages of consistent

mirrorers.

The word 'cat' which was used as the stimulus word presented little difficulty to this dull group. This may partly account for the high percentages showing no mirror when compared with the Visual test.

Likewise more children in the Retarded Group showed partial mirroring on the Visual test but none on the Script test.

The angle of mirroring for both Normal and Retarded Groups on the Script test is very similar.

## Kinaesthetic Test.

On the Kinaesthetic test a higher percentage of boys compared to girls is found in the definite mirroring group, but a lower average angle of mirror is found for the boys than for the girls. The time of learning the pattern is approximately equal for both boys and girls. A smaller percentage of 'no mirroring' is found with the boys. The boys and girls of this dull group both appear to learn on Kinaesthetic clues at approximately the same rate but the girls take longer to mirror. It is interesting that neither boys nor girls show partial mirroring. It would seem thus that a kinaesthetic pattern once learned becomes completely absorbed and reproduced as a total pattern or not at all.

In comparing the time taken to learn the pattern in both Normal and Retarded groups the Normal Group show shorter time. This is not unexpected when consideration

is given to the respective intelligence levels of the groups. Higher percentages of the Normal Group show no mirroring. This may again reflect the case of learning of the groups the pattern being simpler for the Normals. The angle of mirror for both groups is similar.

(C)

Twin Group.

The Twins were then considered in similar fashion to the Normal and Retarded Groups in their results on the individual tests.

Visual Test.

The Twin Group on the visual test show slightly greater percentage of boys in the consistent mirroring group compared with Twin girls. A higher percentage of Twin girls show partial mirroring and they show a higher angle of mirror. Slightly more Twin boys than girls show no mirroring tendency.

In comparing the Normal, Retarded and Twin Groups on the Visual test it is interesting that the group which shows the highest angle of mirror for consistent or definite mirroring tendency is the Twin Group both boys and girls. The non-twin groups show smaller similar angles. It may be that the high sinistral tendency in the Twin Group is creating extra difficulty in perception with a slower rate of learning.

## Script Test.

On the Script test a higher percentage of Twin boys than girls show consistent mirroring with approximately similar degrees of mirroring. No twins show partial mirroring while a higher percentage of girl twins show no mirroring tendency.

In comparing the Normal, Retarded and Twin Groups the Girls show no partial mirroring on this Script test with relatively high percentages in each group for no mirroring tendency. Only 2 Boys from the groups show partial mirroring. Thus there was with this 'taught' and therefore known stimulus, definite mirroring of the total word as a whole or no mirroring.

## Kinaesthetic Test.

On the Kinaesthetic test a higher percentage of boy twins than girl twins show definite mirroring, with a larger angle of mirror also found with the boys. The time taken to learn the pattern is greater for the twin girls than boys. No twins show partial mirroring while a higher percentage of girl than boy twins show no mirroring.

In comparing the Normal, Retarded and Twin Groups only 3 girls and 1 boy in the Normal Group show indefinite or partial mirroring. Thus the Kinaesthetic pattern would appear to be learned totally and not mirrored in part as was apparent on the Visual test. The shortest learning time was taken by the Twin Group with the Retarded Group showing longest time.

## Conclusion.

From the results it is very difficult to identify clear cut trends in the groups on the Van Riper test. It distinguishes a right from a lefthanded child by reason of the opposite hand mirroring and it indicates those children who show inconsistent as distinct from consistent or strong mirroring but the angle of mirroring would appear to be subject to many chance factors and errors, both for boys and girls, a major aspect being the degree of left or righthandedness which an individual shows. If children are developing towards final control of both hands with a cessation or better control of mirror tendency then the angle will tend to vary with age. Likewise the type of pattern, the method of presentation, the sophistication of the subject will all tend to influence the degree at which mirroring occurs.

It is still thus largely a qualitative measure rather than a quantitative one and interpretation of results must therefore be given with caution. The test however differentiates the right and lefthanded with inconsistent mirrorers as opposed to consistent, sufficiently clearly to make it a useful instrument in clinical diagnosis of handedness.

## Summary of Findings on the Van Riper Test.

A great variety of mirroring is present.

Consistent or stable and inconsistent or unstable mirroring found.

Little consistent trend is seen in mirroring among the various categories of hand and eye.

As mirroring tendency decreases, the angle of mirror appears to increase for stable and unstable categories.

Little difference is observed in the composite average degree of mirroring for each group Normal, Twin or Retarded- with little consistent trend.

A higher percentage of boys than girls show definite mirroring while a higher percentage of girls than boys show partial or unstable mirroring.

The angle of mirror for righthanded boys and girls is less than the angle of mirror for lefthanded boys and girls.

### Normal Group.

On the Visual and Script tests the angle of mirroring was higher for the boys than girls. On the Kinaesthetic test the angle of mirroring was equal for boys and girls.

On the Visual and Script tests higher percentages of boys than girls were found in the definite mirroring category. On the Kinaesthetic test equal percentages of boys and girls were found in the consistent mirroring category.

The time taken to learn the pattern on the Kinaesthetic

test was greater for girls than boys.

High percentages of girls and boys show no mirror in the Script test. A higher percentage of boys than girls show no mirror in the Kinaesthetic test.

The average degree of mirror angle is smaller on the Kinaesthetic test than on the Script or Visual test for boys and girls.

Retarded Group.

Equal percentages of girls and boys are found in the consistent mirroring group on the Visual test, but higher percentages for boys are found in this category on the Script and Kinaesthetic tests.

A higher average degree of mirror is found for boys on the Visual and Script tests but a lower average degree of mirror is found on the Kinaesthetic test when compared with girls.

The time of learning the Kinaesthetic pattern is equal for boys and girls and no partial mirroring is found.

Twin Group.

In each of the tests Visual, Script and Kinaesthetic a higher percentage of boy twins enters the consistent mirroring category compared with girl twins. Similar average degrees of mirroring are found for boys and girls on the Visual and Script tests but a higher average degree of mirror is found in the boy twins in the Kinaesthetic test.

The time taken to learn the Kinaesthetic pattern is greater for girl twins than boy twins.

No partial mirroring is observed on the Script or Kinaesthetic tests.

## References.


15. W.E. Cooper and M.E. Bonney - The Validity and Reliability of the Van Riper Critical Angle Board in diagnosing handedness. J. App. Psych. 1942 - 26.

103. Van Riper - A New Test of laterality. J. Exper. Psych. 1934 Vol 17, 305 - 313.

104. Van Riper - The Quantitative Measure of Laterality. J. Exper. Psych. 1935 Vol. 18, 372 - 382.

## Chapter 16.

## Association of Age with Performance on Van Riper Test.

It was desirable to find if mirroring tendency decreased with age. As a child grew older was it possible to state that a tendency to mirror was brought continuously under control till it finally disappeared? Mirroring at a higher degree or greater angle was regarded as being indicative of later mirroring. Was there any significance with age? Hence an attempt was made to find if there was any variation through the differing age groups taken in months with the mirroring tendencies found with each category of hand and eye. This association was measured by the correlation coefficient. The composite score in degrees on the Van Riper test was the measure of mirroring. The relationship of score with age was then calculated for the groups of Normal, Twin and Retarded children, and for boys and girls separately. The Total Laterality group was then considered in similar fashion.

### Normal Group.

Table 93 presents these correlations for the Normal Group.

Table 93.

Normal Group Correlations.

Age with Score on Van Riper.

| Category | Boys | Girls | Boys + Girls |
|---|---|---|---|
| RHRE | -.069 | .229 | .064 |
| RHLE | .086 | .231 | .128 |
| LHRE | .192 | .622[x] | .425[x] |
| LHLE | -.347 | -.130 | -.076 |
| Total | .029 | .357[xx] | .166 |

Two groups in the Crosslateral category of LHRE show significance at the .05 level. The girls show a high positive relationship and the boys and girls of this crosslateral category likewise show relationship. With these groups there appears to be association such that the older children are showing higher scores.

The total girls show a significant relationship also such that the association of score with age would appear more strongly established than with the boys who show no relationship.

No other values are significant.

Twin Group.

The Twins were then considered in similar fashion. Table 94 presents the data.

Table 94.

Twin Group Correlation. (Age v. Van Riper).

| Category | Boys | Girls | Boys + Girls |
|---|---|---|---|
| RHRE | .343$^{xxx}$ | .120 | .207$^{x}$ |
| RHLE | .056 | .242 | .159 |
| LHRE | .069 | -.001 | .084 |
| LHLE | -.181 | .207 | .013 |
| Total | .145 | .155 | .152 |

The pure dextral group of Twin boys show a correlation which is significant at the .001 level. The Total Twin boys and girls RHRE group also show a ratio which is significant at the .05 level. These ratios are positive but although showing some association between age and mirroring, are not high. No other values show significance. The Twin Group as a whole do not show significant relationship with age.

The Retarded Group were then considered, to establish similar relationships. Table 95 presents the data.

Table 95.

Retarded Group Correlations. (Age v. Van Riper).

| Category | Boys | Girls | Boys + Girls |
|---|---|---|---|
| RHRE | .032 | .328$^{x}$ | .131 |
| RHLE | .107 | .201 | .151 |
| LHRE | .339$^{x}$ | .237 | .303$^{x}$ |
| LHLE | -.195 | -.405 | -.238 |
| Total | .094 | .233$^{x}$ | .143 |

The crosslateral category of Retarded boys, LHRE r = .339 and the Retarded boys and girls, r = .303 in this crosslateral group, show ratios significant at the

.05 level. The RHRE girls r = .328 also show a ratio significant at the .05 level. With these categories a relationship with age and score appears although the association ratio is not high. The Total Retarded girls show a positive significant ratio (.05 level). Thus in the Retarded Group the older girls appear to be exhibiting later mirroring than do the boys where no significance is apparent in the totals of boys or boys and girls combined.

Lastly the Total Laterality Group was considered when all boys, all girls, and all the children were investigated in the respective categories of hand and eye. Table 96 presents these ratios.

Table 96.

Total Laterality Group Correlations: Age v. Van Riper.

| Category | Boys | Girls | Boys + Girls |
|---|---|---|---|
| RHRE | .110 | .202$^{x}$ | .153 |
| RHLE | .084 | .311$^{xx}$ | .180$^{x}$ |
| LHRE | .226$^{x}$ | .339$^{xx}$ | .281$^{xxx}$ |
| LHLE | -.195 | .056 | -.097 |
| Total | .102 | .236$^{xx}$ | .164$^{x}$ |

Among the boys ~~in~~ the ratio in the crosslateral category LHRE shows some significance. No other values among the boys show significance. One can conclude therefore that the relationship between age and diminution of mirroring on the Van Riper is not strongly established.

More significance is observed with the girls. The

pure dextrals and more particularly the crosslateral categories reveal positive association. The Total girls likewise show a figure which is significant at the .01 level. Thus with the girls the older appear to be showing greater angle of mirroring or later mirroring.

The Total Group of boys and girls combined show similar significance in the categories of crosslaterals.

For the Total children a small but positive significant correlation ratio appears established. This would suggest that with all the children there is a tendency for later mirroring to occur with increase in age and hence a decrease of mirroring as the children grow older. It might also be that these older children have an awareness of difficulty particularly if they are crosslateral such that a learning factor may be operating also to slow down performance.

Section V

Chapter 17.

SUMMATION OF FINDINGS

Section I

Intelligence and Achievement.

The intelligence level of a total group of 1044 children was investigated and found to approximate to an average grading, with no significant difference found between boys and girls. This group was comprised of three subgroups, a Normal, Twin and Retarded.

The intelligence level of the Normal Group was found to be slightly above average with no significant difference found between boys and girls.

The intelligence level of the Retarded Group approximated to the dull category and was below average. No significant differences in intelligence were found between the boys and girls.

The intelligence level of the Twin Group approximated to the average but was slightly lower as compared with the non-twin Normal Group. The boy twins were found to be significantly higher in intelligence than the girl twins.

In achievement the Total Group of 1044, measured on Reading and Spelling tests were found to be working below average at 87% of their ability. The boys in the Total Group were found to be significantly poorer than the girls.

In the Normal Group while achievement is at a low

average performance for the group the boys were found to be significantly poorer than the girls.

In the Twin Group the same trend is observed where the group as a whole are working below capacity. The boy twins were found to be significantly poorer than the girl twins in language accomplishment.

With the Retarded Group a different picture is seen as this group, although below average in performance, are achieving at capacity. The boys again show a significantly poorer level than the girls.

With the Total Group and each of the subgroups a high incidence of language disability is present as 7% of the total 1044 children show no problem in that achievement is at or above capacity.

The Normal Group show 14% who present no problem in this way: the Twin Group present 12% who show no problem while the Retarded Group show only 3% who relate language ability to capacity. In each case a significantly greater proportion of boys than girls show the impress of language interference.

In the Total Group, the relationship of achievement to intelligence is more marked with the girls and indicates that the girls of higher intelligence are working at a lower level compared with girls who are not so clever.

In the Normal Group again the clever children appear to be doing less well in achievement, compared with those of poorer intelligence in the group.

With the Twin Group the same trend is seen. Those

twins of higher intelligence level are doing less well. This is particularly marked with the girl twins such that the more clever girl twins are doing poorer work compared with those of a lower level.

The Retarded Group or dull group do not show such significance. This group as a whole are working to capacity.

It would seem evident therefore that the general trend shows the dull children to be profiting more in that they are enabled to work to innate capacity, while the cleverer children, be they twins or non-twins, are profiting less well educationally, in that their work is significantly below capacity.

Section II

## Laterality.

### Preliminary hand eye investigation.

The category of hand and eye was superficially investigated for the foregoing Total Group of 1044 children. While no consistent trend is found in the groups the indications suggest that the highest percentages are found with the pure dextral children, i.e. RHRE with the lowest percentages for pure sinistrals, i.e. LHLE. An interesting feature of the laterality is the very high percentage of mixed hand and eye, or crosslaterality, which is present. The boys show higher incidence of crosslaterality than the girls. This is important when one considers the significantly poorer achievement of boys to girls.

The same trend is observed in each subgroup, Normal, Twin and Retarded except that in the Normal Group the girls and boys are approximately equal in percentage for crosslaterality. In every group a higher percentage of righthanded lefteyed children is seen compared with the lefthanded righteyed.

Laterality Characteristics.

The laterality characteristics of a proportion of the Total Group were then studied and a summary of the main findings for this group will be presented in this section.

The Total Laterality Group numbered 770 children, comprising 170 of the Normal Group, 300 of the Twin group and 300 of the Retarded Group.

Laterality characteristics of this group with more intensive tests showed the highest percentage to be in the pure dextral category with more girls than boys, while the lowest percentages were found in the pure sinistral category. A consideration of hand alone revealed more lefthanded boys than girls. High percentages of crosslaterality again were found and again more boys than girls were evident. Thus more boys than girls appear to show indefinite dominance or lack of correspondence of hand and eye.

A consideration of the three subgroups revealed the highest percentage of coincidence of hand and eye to belong to the Twin Group with also the smallest percentage of mixed hand and eye. More girl twins than boy twins show coincidence of hand and eye.

The highest percentage of crosslaterality was found with the Retarded or Dull group while the lowest percentage of coincidence of hand and eye was found with this group.

The Normal Group showed percentages midway between the Twins and Retarded for these categories of hand and eye.

The categories of hand and eye for the Total Laterality Group and the subgroups of Normal, Twin and Retarded did not appreciably alter when non-retarded children were withdrawn from the respective groups.

Non-retarded Group.

The non-retarded children, 120 in number, were considered alone with reference to their laterality. Their intelligence level approximated to the dull grading. The laterality of this group closely approximated that of the Retarded Group which is also one of dull children. A high percentage of crosslaterality was observed with a very high amount of pure sinistrality.

Both retarded and non-retarded groups therefore showed similar trends in their characteristics of hand and eye.

Eyedness.

The eyedness of the Total Laterality Group and subgroups established a uniform pattern in that the highest percentages found were for righteyed children, compared with lefteyed. The highest percentage of lefteyed children was found in the Retarded Group with the highest percentage of righteyed

children found in the Twin Group.

Intelligence, Achievement and Laterality.

The relationship of intelligence with the respective categories of hand and eye was then examined for each subgroup.

The Normal Laterality Group presented an intelligence level at average grading with a slightly higher level for boys. Hand and intelligence level were examined for boys and girls to establish significance. No significance was found. The eyedness of the group was then examined in its relationship to intelligence level but no significance was found for boys or girls. The influence of crosslaterality compared with coincidence of hand and eye was then examined. No significance was found. Finally crosslaterality was examined alone in its relationship to intelligence level. No significance was found for either boys or girls.

A conclusion was therefore drawn that hand or eye were not exerting much effect on this Normal Group in relation to intelligence level.

The relation of hand and eye combinations with Achievement was then examined. The group was found to be working at a low average grading with boys achieving at a lower level than the girls. The categories of hand and eye were examined in relation to this achievement. The influence of hand alone was studied separately for boys and girls. A significant value was found for righthanded girls compared with lefthanded such that the righthanded appeared to be achieving at a

higher level than the lefthanded. No significant value was found for the boys. The eyedness, i.e. right and left eyedness of the group was then compared in its relationship to achievement. No significant values were found for either boys or girls. The crosslateral groups were then compared on achievement with the groups showing coincidence of hand and eye. No significance was found for either boys or girls. Finally the crosslaterals were compared with each other i.e. RHLE with LHRE and their effect on achievement. A significant value was found with the righthanded lefteyed group for girls as compared with the lefthanded righteyed such that the righthanded lefteyed group appeared to be achieving at a higher level. No significance was found with the boys.

In the Normal Group therefore a conclusion must be drawn that hand and eye combination are exerting no significant effect on achievement with the boys. Likewise with the girls, only the righthanded group and more particularly the righthanded lefteyed show a significant relationship.

The Retarded Group was then examined in respect of the intelligence and achievement level, with laterality characteristics. The mean intelligence level of the group as a whole is in the dull category both for boys and girls. The categories of hand and eye were examined in relation to effect on intelligence as with the Normal Group: firstly hand, then eye, crosslateral with 'pure' children, i.e.

those children showing coincidence of hand and eye, and finally crosslaterals alone. No significant values were found for any of these categories, for boys or girls in relation to the intelligence level of this Retarded Group.

The laterality of the group was then examined in relation to their achievement. The achievement level of the group as a whole is below average but the work is well up to and at the mental capacity of the group with girls achieving at a slightly higher level than the boys. The influence of hand, eye, crosslateral with pure categories and crosslaterals alone, was examined with achievement. One significant value was found in the comparison of pure with crosslateral girls. This indicated that the girls showing coincidence of hand and eye were achieving at a significantly higher level than the girls showing mixed hand and eye. No significance was found for the boys. In general one can conclude that the combinations of hand and eye are exerting no major effect on the achievement level of the Retarded Group, with the exception of the group of 'pure' compared with 'crosslateral' girls. There the difference is in favour of the 'pure' category or coincidence of hand and eye.

The laterality of the Twin Group was then examined and the relation with intelligence and achievement level investigated. The intelligence level of the group approximates to the average with a higher intelligence level shown for the boy twins. The influence of the hand

eye categories on intelligence level was examined as with the Normal and Retarded Groups. The handedness, eyedness, coincidence of hand and eye with mixed hand and eye and finally categories of mixed hand and eye were each compared for boys and girls. No significance was found with any of the categories in relation to intelligence level. A conclusion must be drawn therefore that categories of hand and eye have no effect on the intelligence level of the twin group.

The laterality characteristics were then compared in their relation to achievement, to ascertain, if any significant effect was present on the performance in the reading and spelling tests. The accomplishment level of the twin group is below average with the boys achieving at a lower level than the girls. Categories of hand and eye were then examined and compared as with intelligence. The righthanded were compared with the lefthanded, the righteyed with the lefteyed the 'pure' with 'cross' and finally the crosslateral categories compared with each other. No significance was found with the girl twins, but two significant values emerged with the boy twins. The righthanded compared with the lefthanded boy twins showed significance with achievement such that the lefthanded boy twins appear to be achieving at a higher level than the righthanded. Secondly significance was found for the 'pure' with 'cross' comparison for boy twins such that the crosslaterals or boy twins with mixed hand and eye were found to be achieving at a higher level than the 'pure'

group or those boy twins showing coincidence of hand and eye. In general with the twin group, hand and eye show no effect on intelligence and little on achievement except with these categories of boy twins.

The significance of laterality throughout the three subgroups, Normal, Twin and Retarded, conforms to no particular order. One must conclude therefore that hand and eye have little effect on accomplishment or intelligence for these groups.

Comparison of Groups.

The subgroups, Normal, Twin and Retarded were then compared with each other for significant differences on intelligence test and achievement and in relation to the laterality of the groups.

The Normal group was compared with the Twin Group for intelligence test rating and t-values found for right and lefteyed groups, for crosslaterals and for those children showing coincidence of hand and eye. Likewise values were found for righthanded and lefthanded children in the two groups. The values were not significant with the exception of the crosslateral boys category. There the value indicated that the crosslateral boys of the Normal Group showed a higher intelligence level than the crosslateral boys of the Twin Group. The second significant value was found in the righteyed category. The value for the girls indicated significance such that the Normal girls who were righteyed showed a higher level of intelligence than the righteyed Twin girls.

These categories of hand and eye were then considered with reference to the achievement of the groups. The Normal was compared with the Twin Group but no significant values were found. The two groups appear thus to be working at similar levels.

The Normal Group was then compared with the Retarded Group to assess differences in intelligence test and in achievement. Each value in the varying categories of hand and eye with regard to intelligence was found to be highly significant. Thus the Normal Group in all its aspects is of higher intelligence than the Retarded Group. The figures also indicated that a greater difference in intelligence level was present between the Normal and Retarded boys then between the Normal and Retarded girls.

A similar comparison was made in respect of achievement, between the Normal and Retarded Groups. The values were each significant with the exception of the category of lefthanded girls. This value indicated that the lefthanded Normal girls were achieving at the same level as the lefthanded Retarded girls and even slightly below the Retarded Group in comparison with innate capacity. One can conclude therefore that there are real differences in the achievement of the Normal and Retarded Group with the Normal Group showing higher achievement. As with the intelligence of these groups a greater difference exists between the achievement of the Normal and Retarded boys, than between the Normal and Retarded girls.

The Total Laterality Group was then examined alone, in its categories of hand and eye in respect of intelligence and achievement. All righthanded children were compared with lefthanded: all righteyed children were compared with lefteyed: all categories of coincidence of hand and eye were compared with all the crosslateral children and finally all the righthanded lefteyed children were compared with all the lefthanded righteyed. These comparisons were made respectively for boys and girls separately and finally for all the children. The comparisons with respect to intelligence level revealed only two significant values. The righteyed compared with lefteyed boys showed a value in favour of the righteyed boys showing higher intelligence. Again the total, boys plus girls, comparison of right and lefteyedness, indicated a result in favour of the righteyed boys plus girls being slightly superior in intelligence to the lefteyed boys plus girls. Apart from these differences in eyedness with intelligence, no other value was found significant.

The same categories of hand and eyedness were considered in relation to the achievement of the boys, girls and boys plus girls. Only one value was significant and that for girls alone. The comparison of the cross with pure group indicated that the 'pure' group or the girls showing coincidence of hand and eye were achieving at a higher level than the girls showing mixed hand and eye.

The main trend of the Total Laterality Group shows that hand and eye have little effect on intelligence or

achievement.

Sex Difference and Laterality.

The three subgroups, Normal, Twins and Retarded were then examined to ascertain any sex difference in laterality. The frequencies were examined on the $X^2$ test and the boys and girls compared in each group. No significance was found. A conclusion must be drawn therefore that no significant sex difference is apparent in laterality. The boys in the Normal, Twin and Retarded Groups, do not differ significantly from the girls in each group, by reason of their laterality only.

Association of Intelligence with Age.

The three subgroups were then considered in their relationship of age with intelligence test result, in an attempt to find out if the older children were showing a higher intelligence level. The correlation coefficients of each group were calculated, for boys alone, girls alone and boys with girls. This was done for each category of hand and eye, e.g. RHRE, LHLE, RHLE etc.

The Normal Group showed only one significant ratio. The crosslateral boys LHRE showed a negative but significant association, such that it could be inferred that the older boys of this group showed a lower intelligence level. No other ratios were significant. Age therefore, does not appear to be affecting the intelligence result of the Normal Group as a whole.

The Twin Group was analysed in the same way as the Normal Group. None of the correlation coefficients were

found to be significant. Age level is thus not affecting the intelligence level of the Twin Group.

The Retarded Group was then considered in its categories of hand and eye, with age and intelligence quotient. The boys of the pure dextral group, i.e. RHRE, and the total children in the pure dextral category were found to show significant values. These ratios were also negative. The values for total boys alone and total girls alone show significance, the boys showing negative association while the girls show a positive association. These values are not high. No other ratios were found significant, hence age on the group of Retarded children as a whole does not appear to be exerting a major effect on intelligence level.

The Total Laterality Group was then examined for the influence of age on I.Q. rating. All the boys were considered in their hand eye categories: all the girls, and the total children in each category. The boys alone show no significance such that one can infer age is not operating with them on intelligence test result.

The girls show one significant ratio. The category of righthanded lefteyed girls shows some positive relationship such that the older girls of this group tend to show higher intelligence test levels.

With the Total children the crosslateral category RHLE shows a small but positive association with age and intelligence test result.

The relationship of age with intelligence over the three groups shows negative and non-significant relationship. Thus age does not appear to be influencing intelligence test result.

The Association of Age with Accomplishment.

The association of age with accomplishment was investigated to determine how achievement might be affected in the categories of hand and eye with the age of the child. This was investigated for the three subgroups, Normal, Twin and Retarded and again for the Total Laterality Group.

The Normal Group was considered in its varying categories of hand and eye and separately for boys, girls and boys with girls. No significant ratios were found. Age therefore does not appear to be affecting the achievement of the Normal Group.

The Twin Group was then considered in its aspects of hand and eye. Two ratios only were found to be significant. The pure dextral twin girls, and the total dextral twin boys plus girls show high significance in the ratio found. With these groups as the ratio is positive there appears to be an association between age and achievement, such that the older children are tending to show better result in the Reading and Spelling test combined. The twins in the other categories of hand and eye do not appear to be affected in accomplishment by age.

The Retarded Group were then considered. The sole significant correlation was found for boys in the pure

sinistral category. This association indicated that the older sinistral boys were achieving at a higher level in work compared to the younger. No other categories showed significance. In general therefore age does not appear to be influencing the achievement of the Retarded Group.

Lastly the Total Laterality Group was examined for association with boys, girls, and boys with girls. The boys alone show no significant ratios. The girls alone show one significant value for the pure dextral group. This ratio suggests a positive association with age and achievement for this category. With the Total children the ratio in the pure dextral category is again significant. Also with all the children a small though positive association is seen with age and achievement.

Taken as a whole the association of age with achievement is mainly negative and non-significant. Thus a conclusion can be drawn that little relationship exists in the various categories of hand and eye between the age of children and their achievement.

Shifthanded Group.

The children who showed inconsistent handedness on the Performance and Van Riper tests or who revealed lefthandedness on the Van Riper while righthandedness on the Performance Tests were classed as a shifthanded group. There were 199 such children. They were studied separately as a group in an attempt to estimate the effect

of shifthandedness on achievement.

The mean intelligence level of the group entered the low average grading for both boys and girls. The mean achievement level showed poorer performance with the boys, while the girls approximated to capacity with a low average performance.

The inconsistency of hand found for the Normal Group was 19% with more boys than girls showing inconsistency.

With the Twin Group 24% showed inconsistency with equal percentages for boys and girls.

With the Retarded Group 31% of the number showed inconsistency with more boys than girls.

In estimating the effect on schoolwork of shift of hand the frequencies were examined by means of the $X^2$ test for each group. The results indicated that for boys, shift of hand does cause retardation. With the girls no definite conclusion could be drawn.

Laterality and Speech.

The cases of speech defect among the Total Laterality Group were noted. Of the total group 6.62% children showed speech disorder. Of this percentage 2.20% were cases of shifthand, as recorded by inconsistent hand on the Performance and Van Riper tests. More boys than girls were found with speech difficulty, there being 7.69% boys and 5.27% girls in the total group. The Twin and Retarded Groups showed similar percentages of speech cases while fewer were found in the Normal Group. In each group a higher number of boys than girls were found. The

highest percentage of cases was found in the crosslateral categories in each group. No cases were found in the ambi-handed categories. Speech disorders thus showed highest incidence where poor dominance was apparent, i.e. with the crosslateral categories and again one third of all the cases showed shifthandedness. The association of shifthandedness with speech difficulty was examined but no significant relationship was definitely established.

Twins in Family Pairs.

The Twins were then investigated in family pairs, boy twins, girl twins and boy and girl twins. Two groups of like-sexed and one group of unlike sexed twins were available for study totalling 150 pairs of twins altogether.

The intelligence level of the pairs was examined. The unlike sexed twins showed a higher level of intelligence than the like sexed. Of the latter the boy twins as a group showed a higher level of intelligence than the girl twins as a group. The intelligence level of all the groups approximated to the average.

The accomplishment levels of the three groups of twins were examined and found to enter the low average grading. The unlike sexed twins in relation to ability were achieving at the lowest level; the boy twins were poorer than the girl twins in family pairs.

The handedness of the twins was considered and the highest incidence in each group was found where both twins were righthanded. The incidence where one twin was righthanded and the other lefthanded was found to be

greater with like sexed than with unlike sexed twins. The girl twins alone showed a very high incidence where each member was lefthanded.

The twins were then considered re eyedness. A higher incidence of like sexed twins showed one member to be righteyed and the other to be lefteyed. This was not found so strongly with unlike sexed twins.

The laterality of the twin pairs was investigated in terms of older and younger twins. The association between the hand and eye was investigated by means of the $X^2$ test. The association was investigated over the complete combinations, i.e. RHRE, RHLE etc. The handedness was then examined with the eyedness to find any association between older and younger, and then as with the previous examinations, a pure group, i.e. one showing coincidence of hand and eye, was compared with the crosslaterals and finally the two categories of crosslaterals were compared. These examinations were made for older and younger twins, in the boy twin group, the girl twin group and the boy and girl group. In the latter the examinations were also made where the girl was the older and where the boy was the older. None of the values were found to be significant. The pure cross comparison alone yielded a high but non-significant value. This would imply that if the one member shows coincidence of hand and eye the other would tend to show mixed hand and eye. With these groups of family twins generally, little association of hand or eye is seen between the older and younger member of a pair.

The correlation coefficients were calculated for older with younger twins and for each group. This was done with intelligence level and accomplishment to examine the association. All values were found to be significant. The values between like sexed twins were found to be higher than for unlike sexed twins.

The older and younger twins were then compared and t-values found for differences in intelligence test and accomplishment quotient. Each group was examined. No significant differences were found.

The twin groups were then compared to find any differences in laterality between the older and younger members. The frequencies were examined by the $X^2$ test. No significant differences were found for either of the like-sexed groups or the unlike sexed group. These differences were examined for eyedness and coincidence of hand and eye compared with crosslaterality. No significant differences were found. Finally all older and younger twins were compared. No significant values were found.

A conclusion must be drawn therefore that older and younger twins in the long run, show laterality tendencies of right and left, in the same proportion.

The groups finally were compared with each other on hand, eye and 'pure' with 'cross' comparison. No significant values were found. The value for eyedness, right with left, for unlike sexed twins where the boy is older compared with pairs where the girl is older showed a surprising figure near to significance. Thus the

eyedness of boy and girl twins seems to depend on which is the older twin, a boy or a girl.

Section III

Temperament and Laterality.

Percentages of temperamental ratings were calculated for each group, Normal, Twin and Retarded in each category of hand and eye. This was done separately for boys, girls and total children. The categories of hand, eye, crosslateral with pure groups and crosslaterals alone were then a) analysed with reference to the temperamental rating frequencies in each category. $X^2$ values were obtained to find relationship between handedness and eyedness and temperament: b) the sex difference was examined to find if the boys differed significantly from the girls in temperament: c) finally the groups were compared with each other to find if there were differences in the ratings between the groups.

(A)

Normal Group:

A significant value was found with the comparison of crosslateral children with Pure Dextrals or Sinistrals. The groups showing coincidence of hand and eye tended to show more stability than the crosslaterals. More of the differing characteristics of 'general instability' were observed with the crosslaterals compared with the pure group. More resistance appeared with the boys than the girls and more in the groups of mixed hand and eye than those of the Normal Group showing coincidence of hand and eye.

Again in the Normal Group a significant relationship

with temperament was observed with the 'eyedness' of the girls only. More stability was shown with the righteyed girls in this group while more anxiety appeared to be present with the lefteyed girls. More resistance also was present with the lefteyed girls.

Handedness did not appear to be significant with temperamental rating for boys or girls in the Normal Group.

Retarded Group:

A significant value for handedness for both boys and girls was observed with the Retarded Group. More stability was apparent for righthanded children in this group with a high percentage of resistance present with the lefthanded. More anxiety was also present with the lefthanded boys and girls.

Twin Group:

A significant value for handedness was found with the boy twins. A similar trend was observed with the twin boys in that more stability was observed with the righthanded twin boys than with the lefthanded. More of the 'resistance' characteristic was also present with the lefthanded boy twins.

In considering the Total boys of all the groups combined a highly significant value for handedness and temperamental rating was observed. More stability was present with righthanded boys in the Total Group and much more resistance characterised the lefthanded boys compared with the right. Likewise a slightly higher percentage of neurotic tendencies was observable with the lefthanded boys.

(B)

In testing for sex difference highly significant values were found for both the Twin Group and the Retarded Group. Thus with these groups a definite difference exists between the boys and girls on temperamental rating.

In the Twin Group this difference was evident in the much higher percentage of stability with the girl twins compared with the boy twins. Likewise more of the characteristic of 'resistance' appeared with the boy twins with more anxiety and neurotic tendency.

The crosslateral boy and girl twins also showed a highly significant difference in keeping with the main trend for the boy and girl twins.

With the Retarded Group a highly significant difference was found between the boys and girls on temperamental rating. The Retarded girls showed more stability than the boys. Again more 'resistance' was shown with the boys than with the girls. More boys were found in the delinquent and neurotic classifications with more of the girls showing anxiety and inhibition.

Within the Retarded Group the pure dextral category showed a significant difference for boys and girls. This particular group of girls appeared to contain more of the delinquent and neurotic type and may be a special group referred specifically for these characteristics.

(C)

When the groups as a whole were compared with each

other, the values revealed high significance.

The $X^2$ values for a comparison of the Normal with Retarded group were all highly significant. In general these differences revealed much more stability with the Normal Group compared with the Retarded. Much more 'resistance' with the Retarded Group as also characteristics of anxiety, delinquency and neurosis.

Comparison of the Normal with Twin Group revealed similar trends to the Retarded comparison. More stability was present with the Normal Group compared with the Twin Group with more characteristics of anxiety, instability delinquency and neurosis among the Twin Group. These characteristics were found for both boy and girl twins compared with Normal boys and girls.

The groups as a whole showed a general trend of more stability in the Normal Group, with least in the Retarded Group. The Twin Group was found midway between the two extremes. Most 'resistance' was shown with the Retarded Group with least in the Normal Group. Most anxiety was shown with the Twin Group, with least in the Retarded Group. Least delinquency was found in the Normal Group with most in the Retarded; likewise the highest frequency for neurotic tendency was observed with the Retarded Group, followed by the Twin Group. Boy twins showed significant differences in handedness compared with total children, thus the temperamental ratings differed

significantly. Being a twin therefore appears to have an effect on temperament.

In general it was observed that the children showing most dominance, tended to be the most stable. The Retarded Group which is characterised by a high percentage of children showing mixed hand and eye and shifted hand was also the group which revealed most instability and most resistance with characteristics associated with neurotic and delinquent tendencies.

## Section IV

### Performance Tests.

The individual tests showed greater inconsistency with one exception, than the amount of inconsistency found for a composite score. Each subgroup Normal, Twin and Retarded revealed inconsistency.

The girls generally showed poorer scores than the boys. The preferred hand in every case showed a higher score than the non-preferred.

The difference between the hands tended to be greater

for boys than for girls, hence boys showed stronger unimanual preference. Least difference between the hands was observed in the Retarded Group.

The scores for the Normal and Twin Groups tended to be higher than for the Retarded Group, but the group percentage scores were in every case low.

Van Riper Test.

The Van Riper Test was presented in its three aspects, visual, script and kinaesthetic. The children in each group tended to reveal themselves as stable or consistent mirrorers and partial or inconsistent and unstable mirrorers. Much variety of mirroring was shown. Little consistent trend was found for the mirroring among the various categories of hand and eye. As mirroring tendency decreased, the angle of the mirror appeared to increase for both consistent and inconsistent categories.

Little difference was observed in the composite average degree of mirroring for each group Normal, Twin and Retarded with little consistent trend. A higher percentage of boys than girls showed consistent mirroring, while a higher percentage of girls than boys showed inconsistent and partial mirroring. The angle for lefthanded boys and girls was greater than the angle of mirroring for righthanded boys and girls. On the visual test, a higher percentage of boys than girls was observed in the consistent category in the Normal and Twin Groups, but equal percentages of boys and girls entered the consistent category in the Retarded Group.

Higher average degrees of mirror on the visual aspect were found with boys in the Retarded and Normal Group but similar average degrees of mirroring were apparent with the boy and girl twins.

On the script test a higher percentage of consistent mirroring was seen in each of the groups, Normal, Twin and Retarded for the boys compared to the girls. Only in the Normal Group was a higher average degree of mirroring observed for boys compared with girls. Both in the Twin and Retarded Group the girls showed a higher average degree.

On the kinaesthetic test the boys in the Twin and Retarded Groups showed a higher percentage of consistent mirroring but equal percentages were seen for boys and girls in the Normal Group. The time taken to learn the pattern was greater for Twin and Normal girls compared with boys but equal for boys and girls of the Retarded Group.

Thus it is difficult to identify clear cut trends in the groups.

The Van Riper test distinguished a righthand child from a lefthand child by reason of the opposite hand mirroring. It also indicated those children who appeared to show consistent and clear dominance from those who showed alternation and inconsistency or partial dominance but the angle at which the mirroring occurred appeared to be subject to many chance factors and errors, both for boys and girls.

Age with Performance on Van Riper Test.

The subgroups were examined with reference to age and degree of mirroring on the Van Riper test, to find if older children showed a higher average degree of mirroring or not. The association was calculated by the correlation coefficient and was made for boys and girls separately, together with boys plus girls for each category of hand and eye.

The Normal Group showed a significant ratio for the crosslateral LHRE girls and also for the crosslateral total children of the Normal Group LHRE. With these groups an association was present with their age and performance on the Van Riper. No other ratios were found significant. In general therefore age is exerting no major effect on performance with the Normal Group.

The Twin Group were likewise examined. Two ratios only showed significance. The group of Twin dextral boys i.e. RHRE showed a significant correlation while also the total Twin boys plus girls in the dextral group showed significance. There appeared to be an association with age and performance with these categories. No other category showed significance. In general thus one can conclude that the Twin Group is not influenced by age in its performance on the Van Riper.

The Retarded Group were then considered in the same way. With this group three ratios showed significance. The crosslateral group of boys LHRE and the total crosslateral

group of Retarded boys plus girls both showed significance. The dextral girls likewise showed a significant ratio. With these categories one can accept a relationship with age and performance although the ratios are not high. No other category revealed significance.

Finally the Total Laterality Group were examined. Boys alone, girls alone and total children were considered in the various categories of hand and eye. Among the total boys one ratio was significant. The crosslateral group LHRE showed significance. Among the total girls the pure dextrals showed a significant ratio. The two groups of total crosslateral girls, i.e. RHLE and LHRE, showed significance also. With the total boys plus girls the respective crosslateral groups again showed significance although the association was not high. Finally the total girls considered alone showed a significant association at the 1% level while all the children showed a small though significant ratio indicating that the older children tended to show later mirroring. The correlations found significant were all positive and suggest a significant relationship of age with mirroring particularly with the crosslateral groups. It would suggest that these older children show a higher average degree of mirroring or later mirroring hence the suggestion is that mirroring decreases with age.

## Chapter 18.

## Survey of Field - Theories.

From the preceding review it is apparent that no single theory or simple explanation will account for the varying trends and diverse nature of laterality as observed. Accordingly the problem will be surveyed in the light of the main theories which have been proposed by earlier workers in this field and the results will be examined in the light of the following four main approaches to the problem although it is impossible to regard each approach as separate and distinct. Factors in laterality appear too varied and intermingled.

It has been shown by earlier writers that handedness is a matter of degree determined by the skill with which both hands are used, every physically normal person being lefthanded to some degree. Burt 1937 (11) Brain 1945 (7) Koch 1933 (52) Durost 1934 (25) Heinlein 1929 (39) have shown that there are different combinations and patterns of handedness in different individuals even within the same individual. Thus problems of laterality have become wider and more complicated then earlier writers on handedness suspected.

In general, investigations of Laterality have followed four broad paths with much overlapping.

a) A conception of the problem as one of Training and Social Usage.

b) A conception of the problem as one of Growth and Maturation.

c) A conception of the problem as one of Neurological and Constitutional Factors.

d) A conception of the problem as one of Heredity and Foetal position.

Consideration of each point of view may reveal certain common factors which will help to elucidate the complexity of the problem as found in the previous chapters.

(a) A Problem of Training and Social Usage.

Downey 1933 (23) thinks that Laterality is the product of social cultivation and the result of habit or custom. Handedness is habitual behaviour operating through the growth period. She thinks that parents and the child's early environment are his teachers in acquiring handedness just as in speech. The most recent exponent of this view is G. Hildreth 1949 (43) who thinks that righthandedness is a cultural or social convention to which most people are trained or find it expedient to conform. She thinks that lack of efficiency and confusion would result if half of the world were righthanded and the other half lefthanded. Similarly individuals who have not achieved manual dominance are less effective and may even be handicapped in motor performance. Hildreth thinks that the best explanation of handedness is that people are right or left because they have learned to be and not

because they were born that way. This would appear to be an oversimplification of the problem and tends to disregard entirely the wide field of the biological sciences together with much work which has been done on the heredity aspect.

Dr. Burt, 1937 (11) states that with age, the individual shows increasing self consistency due largely to strengthening of habit through learning and social influences.

The arguments for the theory of Social Convention as an explanation of handedness are that there is more prestige value attached to righthandedness with discrimination against the lefthanded, which springs from olden days when lefthandedness was held in suspicion and regarded as a sign of abnormality. This attitude has now given way to ideas of free expression and liberty of action so that the numbers of lefthanded children have increased during the last 25 years. As everything in the world is arranged for the righthander, the advantage of being so is self-evident. Lefthanded children are handicapped in school because most teachers tend to be righthanded and the children require to imitate modes of action which are difficult for them. Yet it is also stated by Hildreth that young children are easily trained away from the left hand with a decrease in lefthandedness from infancy till adulthood. Boys appear to show a greater percentage of lefthandedness than girls this is again attributed to social influence. Few people

are consistently leftsided and eye and hand dominance are not in agreement in a large percentage of the population. There is a suggestion that crosslaterals are in reality shifted sinistrals. Brain 1945 (7) thinks that training may cover over natural tendency, and that the percentage of lefthanded people born so, is possibly much higher than those who know they are lefthanded.

Further arguments are that mental defectives tend to be nearly fifty-fifty in right and left hand or ambilateral because they are less trainable. The work of Gordon 1920 (35) and Mintz 1947 (67) suggests this. Untrained animals tend to be ambidextrous. The inference is therefore that progress in handedness shows gradual influence of social convention increasing in its strength with the age of the individual - the bias being towards righthandedness. This does not explain why the bias is unable to influence many strong lefthanders, or why, in some people, having achieved shifted sinistrality, they do not appear to achieve at a level as high as pure dextrals.

(b) Problem of Growth and Maturation.

Young infants cannot show handedness until their motor apparatus matures and the nerve fibres conducting the muscles are developed. Studies have been made to show that in earliest infancy the physically normal child is bilateral and that hand dominance is a developmental sign during the early childhood years.

J.B. Watson 1919 (109) used a test where the tendency of the baby to support its weight and cling, was used.

He found no steady predominance of either hand established. Giesecke 1936 (33) summarised data where hand preference in infants alternated up to thirty six (36) weeks and then the right hand predominated at forty (40) weeks until twelve (12) months. Lippman 1927 (57) found at 4½ months the right and left hands were used equally. From this time to 12 months he found a gradual increase in the tendency to use the right hand. Voelckel 1913 (107) tested 52 children aged 3½ years to 17 months with tests reaching for objects - each child was given about 50 trials. There was no hand differentiation till 7 months then the first of his subjects showed right dominance, and from then on, the superiority of right hand dominance was noted. Giesecke also reported that 35% of the infants showed more left dominance than right. The suggestion is made that development towards righthandedness is taking place between the first and second year of life - when self feeding begins. Social factors and pressure are thought to be operating also. Gesell and Ames, 1947 (28) by photographic records conclude that handedness is a product of growth. Gesell thinks it is important to inquire into the various developmental expressions of laterality and approaches the whole subject from the standpoint of autogenetic patterning and organisation. He thinks that the acquisition of lateral dominance does not take a straight line course. He found from his examinations that 2½ years was of special interest from the standpoint of laterality and that there occurs marked shifts in

handedness from age to age, particularly in the first year of life. Gesell thinks that the earliest manifestations of human handedness are in some way bound up with the phenomena of the tonic neck reflex, i.e. an attitudinal behaviour pattern which figures fundamentally in the mechanics and morphogenesis both of locomotor and prehensory movements. The head and neck very early exert a controlling influence upon the attitudes assumed by the limits of the torso. He thinks that all infants do not assume an equally emphatic right or left tonic neck reflex, but studies of full term and premature infants indicate an unmistakable predilection to rightward orientation. Therefore does a right tonic neck reflex predict righthandedness and a left tonic neck reflex lefthandedness? Gesell tends to think so. Gesell and Ames think that the bipolarity which bisects the Emersonian universe bisects also the organisation of laterality in a growing organism. Two pairs of opposing trends bilaterality versus unilaterality and right versus left are in 'developmental flux'. But the flux is partly channelised by virtue of the 'principle of functional asymmetry'. Perfect ambidexterity, if it exists at all, would seem to be an abnormality because effective attentional adjustments require an asymmetric focalisation of the motor set. Therefore all normal children tend to be right or lefthanded and handedness is thus a product of growth.

In the Infant and Pre-school child, Ames 1942 (3) thinks that definite periods of unilateral arm behaviour

alternate with periods of bilateral, regardless of postural orientation. She thinks these alternating periods are a basic pattern of growth and not merely a phenomenon of arm behaviour as they can occur in leg as well as in arm postures, in supine as well as prone posture and that the evidence points strongly to the conclusion that the primary forces which configure the movements and stances of infant posture are intrinsic, endogenous.

Updegaff 1932 (102) observed 40 nursery school children between two and six years and found 12.5% used the left hand more than the right hand with much more variability in bimanual than unimanual activities. Lefthanded children used the right hand more often than righthanded used the left hand and more consistency was found in taught activities than in those untaught or unpractised. H.E. Jones 1931 (49) used Merrill Palmer Tests in studying 60 pre-school children. Dextrality ratios tended to be higher for girls than for boys and rate of increase tended to be higher for girls than for boys and rate of increase with age, higher for girls. Downey 1928 (22) observed 47 nursery school children and found less stable reactions than are found in adults. According to Downey, many hand habits have become stabilised by four or five years and there is little fluctuation after that time. Two studies by Heinlein 1930 (40) of 24 children of nursery age and older children reported degrees of handedness rather than two distinct manual types of right and left. Two thirds

of the children tended to be righthanded and one third to be lefthanded or ambidextrous. Heinlein thinks that positional convenience influences preferential handedness in pre-school children. Hildreth 1948 (42) undertook a study of 44 children which confirmed previous data. She found approximately 11.1% lefthanded children of nursery school level. In all her age groups, 2 - 4 years, she found lefthandedness more common among boys than girls. She tends to explain the handedness largely in terms of training and habit formation conforming to social custom.

(c) <u>The Problem as one of Neurological and Constitutional Factors.</u>

A.H.H. Sinclair (92) in a paper on Developmental Aphasia indicates that failure in word memory (one of the aspects of Orton's Word-Blindness in Children), may be related to delayed development of Myelination of cortical neurons with associated delayed function. Reference to myelination occurs in a paper by Alex. Bruce and James Dawson 1913 (8). The nerve paths in the embryo remain as embryonic nerves till the function of the tract is called into play: influences which accelerate or retard the period at which nerve fibres are brought into functional activity have also an affect in determining the date of complete fibril and myelin differentiation. Differentiation proceeds therefore along with the functioning which is its determining cause. Professor Berry in his

book 'Brain and Mind', 1928 (6) states that it has been shown that myelination does not occur simultaneously in all parts of the nervous system, but is later in proportion as the nerve fibre is more recent in the phylogenetic history of the animal. The entering receptor neurons of the spinal cord are more numerous than the outgoing effector neurons and they also myelinate earlier in order that they may function earlier. The same tends to hold good for the neo-pallial cerebral cortex and these are precisely the seats regarded as being of the higher mental processes. But if these same areas are not stimulated by suitable incoming receptor impulses their association neurons will not myelinate and consequently the areas through life remain 'silent areas' to the detriment of the mentality of the individual. The last series of neurons to myelinate, i.e. to function, are those of the cortex, which correlate and control the extero-ceptive impulses and extend them through the association areas, thus making possible education, speech, thought and reason. If the neurons of this series fail to myelinate, there must follow an impairment of intelligent action. Sinclair states that myelination commences before birth and goes on until well into middle life and suggests therefore that the localised delay or failure in the development of myelination of nerve fibres in the cerebral cortex is the most probable explanation of this developmental failure in learning to read.

Orton 1937 (75) in his Cerebral Dominance theory tends

to accept the myelination process of how a child is slow to read, and describes it as proceeding in three steps. Orton regards cerebral dominance as a neurological condition, due to asymmetrical functioning of the two cerebral hemispheres, one playing the dominant role. Handedness is therefore due to the dominance of one hemisphere. According to Orton only in man is cerebral dominance shown and in many, only in language and intricate manual skills. The Brain dominance theory rests largely on pathology. Cases of aphasia and locomotor disturbances due to one sided paralysis are accompanied by defects in the motor discharges of the opposite side of the brain but according to Orton, injury must occur in the dominant hemisphere before disorders of speech and language occur and the only guide to the dominant hemisphere is the laterality of the individual. The area of the brain damage becomes therefore the important point and not the amount of tissue destroyed. At birth, according to Orton, there is no unilateral superiority of control but most children, from research on generations of families, carry a hereditary tendency to the predominant use of either right or left hemisphere. Orton thinks that the percentage of right and left handed people in the population conforms to what would be expected if the tendency to the right hand served as a dominant hereditable factor in the Mendelian sense. Because hand is subject to training the end patterns are a combination of heredity and environment. Due to the

intermingling of different characters a mixture of right and left sidedness is obtained which Orton calls 'motor intergrades' or crosslaterals. The eye, according to Orton, is a function of motor control rather than of visual acuity because in sighting the act of bringing the macula and the object into one line depends on the extra ocular muscles and he links this up with the great muscular skill developed by the master hand. Evidence of motor intergrading in adults, he takes as indicative of the absence of a sufficiently strong hereditary tendency to establish clear cut preference.

Ballard (5) suggests that eye dominance tests cast doubt on the cerebral dominance theory as an explanation for all sinistral or dextral behaviour as the anatomical relation of the eyes and the two hemispheres is very different from the relation between the hands and hemispheres. The two halves of the retina are represented in both cerebral hemispheres so that impulses from each are intermingled with those from the corresponding half of the other retina.

Parson (77) put forward his Eye Dominance Theory where the sighting eye determined the hand because of a functional limitation of binocular vision, which necessitated the use of one eye for all sighting and aiming operations. Parson thinks that all righthanded lefteyed individuals were originally lefthanded and forced to change. His theory however does not explain the significance of lefthanded righteyed individuals. Also in binocular vision it is impossible to distinguish the field of vision of one eye from that of the other. The two eyes function as one,

nor does his theory explain the handedness of the blind.

Gordon 1921 (35) examined children in Special Schools and found that the percentage of lefthanded children was much higher than in the normal school; 18.2% as against 7.3%. He suggested this excess might be due to instances of disease of the central nervous system reversing the native handedness and leading to intellectual subnormality in many cases.

Likewise Mintz found in studying feebleminded boys in a State Institution that the number of righteyed boys was smaller than in normal groups and the number of crosslaterals was increased, with a large number of lefthanders. In studying reading preferences of these subnormal boys with hand and eye he found that his results were opposed to Orton's theory of a double set of memory traces of visual shape and lack of unilateral cerebral dominance as a major factor in reading disability because there were too many types of reversal errors. He postulates a link with possible hyer-emotionality and therefore excitability of the cortex.

Brain 1945 (7) has found no physiological evidence that the left hemisphere is larger than the right and has discovered no difference in microscopical structure. He is of the opinion that the pathological lefthander is a natural righthander with a damaged brain and is therefore doubly handicapped both by his brain lesion and by having to use the hand which is by nature not skilful. He tends to subscribe to a heredity theory and thinks handedness results

because of the nature of the genes inherited. The idea of the right hand behaving as a Mendelian dominant and the left hand as a recessive appears sound to Brain and he explains apparent discrepancies by tracing seeming righthanders to be in reality shifted sinistrals who were lefthanded by inheritance.

K.U. Smith 1945 (94) in considering Orton's theory of dominance states that anatomically the means of integration of the two cerebral hemispheres is by way of the commissural pathways of the corpus callosum. He supposes that the theory of lateral cerebral dominance implies that the fibre pathways of the callosum determine the inhibitory potentialities of the dominant cortex over the subordinate side of the brain. Smith divided the neurones of the callosum in an attempted analysis of the functions of the corpus callosum in behaviour. His results showed that any one of the three commissural fibre systems of the cortex in man could be divided without major alteration in the individual's bilateral motor organisation. The sections had little or no effect on the laterality of individuals displaying right dominance. Individuals with left or mixed dominance however showed post operative shifts in laterality which greatly exceeded those found in the rightsided cases. These shifts consisted mainly in decreases in the degree of dominance. Most shift was in body orientation and footedness. Eye and writing habits were modified little. He also found that an individual who lacked the fibres of the corpus callosum showed lateral

dominance as a normal individual. Neurologically therefore ocular, manual or pedal laterality seem to be unrelated at the cortical level, for conditions which may effect shift in manual or pedal sidedness do not change at all the ocular dominance of the individual. Lateral dominance in man is dependent on the normal operation of certain areas of the cortex of the contra-lateral side. Different regions of the cortex, subserving specific sensory and motor functions, are involved in the maintenance of sidedness. Smith comes to the conclusion from the above experiment that the commissural pathways connecting homologous regions of the pallium are of little or no significance in determining the bilateral balances of function critical to dominance. It must therefore be presumed that the equalities of function determining laterality lie at the subcortical level and are dependent on commissural connections between the two sides of the brain at this level. Smith believes this to be true of right dominant individuals in manual and pedal activities. But it does not explain why individuals of left or mixed dominance showed greater post operative changes. He feels it may be therefore in those individuals lateral dominance has been defined to a greater extent by learning. He sums up the result by stating that the cortex and its commissural pathways vary in importance in the development and maintenance of laterality in behaviour, according to the degree to which original or inherent sidedness has been modified by training and that the most definite effect will

be upon individuals of mixed or shifted sidedness in whom training has determined many different aspects of dominance in behaviour. He casts doubt on Orton's theory from a neurological angle. If Orton is right then division of the main commissural fibres between the hemispheres should cause dissociation of motor and sensory functions on the two sides of the body and conflict of the two sides in unimanual and bimanual motor co-ordination. This was reported in only one instance. Also Smith found speech disorders in his patients did not arise after the operation but according to Orton's theory there should have been interference. Smith questions therefore whether speech is related as closely as has been suggested to cortical dominance.

Smith prefers to believe that between the different parts of the cortex and subcortical centres there exists an integration of activity and unification of function, providing for organisation of postural activity and transient moment to moment responses. Loss of any part without significant embarrassment to the behaviour of the individual does not prove that normally this division is without importance. It may merely mean that other parts of the mechanism retain their balance and regulated action, or soon recover it, in the absence of a given level of the neural system. It is this multiple integration of activity which explains why normal behaviour and bilateral motor organisation seem to be retained after the two cerebral hemispheres are divorced in man.

Edward T. Raney 1938 (81) investigated twin pairs with the electroencephalograph to find if there were any significant differences between the halves of the respective brains. He found that electroencephalograms of one twin showed bilateral differences the reverse of those found in the electroencephalograms of the other. Also one twin had a tendency to a significantly larger relative difference between the two sides of the head. A hypothesis was advanced that a major factor in the control of the frequency regularity and amplitude of the bio-electric rhythms from the cortical neurones is the 'cortical excitatory state'. The reaction of a given cortical area to excitation through external sense fields is usually characterised by depression of the alpha rhythm, therefore a lesser amount of alpha rhythm might indicate a higher level of excitation. It would appear that since Raney found more alpha activity on the nondominant side of the head, the non-dominant cortex is less activated or less excitable and that lateral dominance may be related to a cortical excitatory state. Further the encephalograms of the two sides of the head were more nearly alike in the left dominant twin and in individuals who do not show strong lateral dominance. Those who have strong dominance tend to have marked differences in cortical excitatory state between the two hemispheres. If it is true that the differentiation between the two hemispheres is a function of lateral dominance then there seems to be evidence for an association of lateral dominance

with the higher forms of neural integration. The difference between the cortical excitatory states in these individuals may be so small that the balance between the two hemispheres is very easily upset. On the other hand in the individual with strong dominance the difference between the excitatory states may be so pronounced that one hemisphere may dominate the other, giving more stability to bilateral neural organisation. This may be related to the fact that there is such a large percentage of left or mixed dominance among the M.D. psychotic or psychopathic individuals.

D.B. Lindsley (56) analysed the records of an encephalogram simultaneously obtained from the right and left occipital regions in 48 righthand, 8 lefthand and 9 ambidextrous children and revealed that the alpha waves in the two hemispheres are out of phase a greater percentage of the time in ambidextrous and lefthand subjects than in righthand subjects, also that there is less unilateral blocking in the righthanded group. He concludes that the higher the degree of asynchronism and blocking in individuals lacking a definite and complete laterality the more interference with speech and language is likely.

(d) The Problem of Foetal Position and Heredity.

J.B. Watson (109) believed the position of the foetus might be a predisposing factor in handedness. Before birth the left arm lies posteriorly and this might give greater facility to the right. But at birth there is no demonstrated preference in the infant population. Postural relationships

between infant and mother have also been suggested, e.g. a mother holding a child on her right arm has the infant's left arm round her neck and the right hand is thus more free.

Orton and Ojemann 1930 (73) believe laterality with the effects of training to be a hereditary trait.

Gordon 1920 concluded that one in four of all children are lefthanded and that this aspect was a Mendelian Recessive Trait. Durost 1934, believed that weight of evidence favours inheritance but environmental training and pressure prevent handedness from following known laws of inheritance.

Burt thinks the inherited bias must be slight else it would not be so difficult to substantiate.

Much of this type of theory has come from the study of twins. D.C. Rife (84) thinks that all twins are characterised by a high percentage of left handedness as compared with the single born. To account for this, Newman 1937 (71) proposed that intra pair differences were due to an asymmetry mechanism. Twins arising from embryos which separated before the primordia of hand was established would have the same handedness while those which separated after, would show intra pair differences. Newman's hypothesis however does not account for the large percentage of lefthanders in fraternal twins. Evidence suggests that handedness in the single born has a genetic basis, e.g. when both parents are lefthanded about 50% of the children are lefthanded. If one parent is righthanded about 6% of the children are lefthanded. (Chamberlain 1928 (12)

Rife 1933 (84)).

Rife observed that twins showing intra pair differences are likely to have lefthanders among their immediate relatives. He investigated 305 sets of twins and their families and showed that in both types of twins, those pairs showing intra pair differences are about twice as likely to have lefthanders among their immediate relatives as are pairs consisting of two righthanders. Rife therefore concluded that high frequency of lefthandedness in both types of twins may be due to the fact that those pairs genotypically intermediate in handedness consist of one righthander and one lefthander, the unusual position of utero being sufficient to influence the expression of functional handedness. Those pairs genotypically strongly predisposed to either right or lefthandedness would not be influenced by position in utero and would show no intra pair differences. Further study by Rife (85) in 1943 on mirror imaging and dermatoglyphics led him to the conclusion that twins and paired sibs show approximately the same degree of asymmetry reversals, thus indicating that conditions in utero peculiar to twins of both types have no effect on bilateral asymmetries or dermatoglyphics.

H.H. Newman (69) explains mirror imaging in twins by his asymmetry mechanism where the two halves of the body are not fully asymmetrical. He states that this is due to the fact that at an early stage of development the left side of the embryo is a little superior to the right side in rate of development. Righthandedness is thus merely an expression of

a slight superiority of the motor centres of the left half of the brain. In identical twins twinning division occurs before the right and left halves of the embryo have begun to grow at different rates, before right - left asymmetry has begun to be established. The explanation for identical twins where one is found to be righthanded and the other lefthanded is that twinning has occurred later in the developmental cycle and the twin derived from the left half of the original embryo will tend to develop a little faster than the other twin and will tend to show the same asymmetries as those characteristic of the species, while the twin from the right half will develop more slowly and tend to follow the opposite plan of asymmetry, which is the mirror image of the twin derived from the left half.
A second theory which Newman propounds is that mirror imaging or cases with situs inversus (reversed internal structures) are explained as due to 'arrested development'. It is only a short step therefore to the conclusion that reversed asymmetry itself is a product of arrested development. A Japanese twin specialist, Komai, also supported this view. He found a high correlation between situs inversus viscerum, under-development and deformity - the result of a common cause, some growth depressing condition in the environment, therefore one may argue that twinning favours reversed asymmetry or that twinning itself and all the accompanying inferiorities are the products of poor environmental conditions that retard development. The differences between the two theories is that according to the first one the

reversal of asymmetry is inherent in the embryo and not due to external environment, and therefore could be explained as a result of conditions peculiar to one egg twinning, conditions neither strictly hereditary nor strictly environmental. The second theory postulates that reversed asymmetry, whether in single individuals or in twins, is an environmental effect.

Thus in all these theories heredity and environment are inextricably bound together. If some growth depressing agent is at work then it would seem that sinistrality or indefinite or mixed dominance should be associated more with the type of individual who is immature, defective or slower in maturation, assuming from embryology that right dominance is more natural. Environmental pressure with consequent shift to the right of many lefthanders would interfere with the 'motor set' of the individual with a consequent imbalance of muscular co-ordination. The brain rhythms would be disturbed hence it seems feasible that the shifted sinistral or crosslateral type should display more instability, a higher cortical excitatory state. Further work with the encephalograph in analysing the rhythmic patterns of the brain would seem a promising field with particular reference to cases of shifted sinistrals or crosslaterals.

## Chapter 19.

### Laterality - Training and Social Usage.

Habit and custom, although contributory only, play an important part in the determination of the preferred hand of the child. The training which each individual receives is also a highly variable factor, but in most cases will lead to the adoption of right handedness because the majority of the population use the right hand. The earliest environmental influence will be largely the home training given to the child, followed by training in school. The attitude to training towards dextrality will be influenced by the degree of prejudice sustained to sinistrality and may vary in parent or teacher from sharp insistence on righthanded usage to a tolerance which allows natural hand tendencies to emerge and left handedness to become established. That both parent and teacher are influenced by the social conventions of a righthanded world would appear evident when the percentage of shifthanded children is considered, yet training alone cannot account for all the facts, as a percentage of children remain who appear to resist all efforts to change from left handedness to right handedness. The question of training thus resolves itself into further conjecture. Are differences in trainable skill innate or is left handedness simply a result of habit or custom? The end result would appear to be a compromise between the two opposing factors as neither can

prove its point. Yet the point of view adopted will influence greatly the attitude to training. If left handedness were simply due to custom and habit, then a decision to train towards right handedness could be made with ease but if, as would appear from the data, an inborn tendency is present related to the temperamental set of the individual then caution is required in the approach. It would seem apparent that no clear cut preference exists between the right and lefthanded. Rather handedness would appear to be a matter of degree ranging from strong dextral preference through stages of indeterminate handedness to strong sinistral tendency. Likewise uniform coincidence of hand and eye was not found among the groups as high percentages of mixed hand and eye were observed. Furthermore handedness cannot be regarded as an entity operating consistently in one task or situation as hand behaviour would appear to vary with situation and circumstance and vary in unimanual tasks from bimanual activity. Tests demanding taught skill are more apt to become tests of unimanual activity while activities of unskilled type are more liable to be performed with either hand. The individual performance tests were influenced by training as they comprised tests of unimanual activity. The influence of the early environment can be seen in the child who picks up a ball with the left hand and then transfers it to the right hand in order to throw it. In the performance tests, many children were observed to pick up pegs for the pegboard in one hand,

transfer them to the other hand before inserting them in the pegboard; similarly with the bean bags, many children changed the bags from one hand to the other before throwing. Natural inclination led them to use one hand while training and habit determined the other. As a result of the indecision over which hand to use and the interference due to training with the indirect approach to the goal, these children did not score so highly as others who showed no hesitation with handedness. Agreement can therefore be found with Hildreth that individuals who have not achieved definite dominance are handicapped in motor performance as indecision with confusion over which hand to use, tends to slow down performance. The effect of training as observed from results achieved by the preferred hand when compared with the non preferred appeared to indicate that the trained hand or the one most habitually used, was also the more accurate, as in many cases the preferred hand was not the native hand. Strength of preference as thus defined in terms of degree of difference in skill was most apparent in these tests of unimanual activity and particularly in boys compared with girls.

Hand preference in bimanual activity tended to vary more. A test of bimanual activity where the complementary use of both hands was demanded with one hand dominating did not wholly support Hildreth's statement that 'people are right or left handed because they have learned to be and not because they were born that way'. An examination of

results showed high percentages of both boys and girls who were born with definite sinistral trends which were sufficiently strong to resist complete change, hence a large percentage was found of mixed hand and eye cases and indefinite hand cases. On the other hand comparison of the results of 'acquired' hand activities with results of 'innate' hand activities revealed the 'shifthand' group and this group would lend support to Hildreth's belief that people are righthanded because they have learned to be. Thus while it is true that children reveal handedness which is acquired, it is equally true that a percentage of children resist all training or attempts to change their handedness from left to right. The tests given were mainly those which involved the finer muscles of the hand and fingers which would be most susceptible to training and with these right handedness among the children emerged more obviously than left handedness.

Few children showed ambidexterity; thus it would seem evident that preference for one or other hand becomes established with increasing age as the groups studied approximated to an 11 year level. Agreement can therefore be found with Burt and other workers that increasing self consistency can be found with age. Consistency or strength of hand dominance appeared more strongly with boys than girls on the Van Riper Test and may be a reflection of the strength of habit training in boys when compared with girls. This variation between the sexes on the Van Riper is

likewise interesting when one considers Burt's findings, in Mental and Scholastic Tests, that mirror writing is more common among girls than boys. Decrease in mirroring with age on the Van Riper, suggested that the older children showed later mirroring. If later mirroring is regarded as an indication of greater control then it would appear that the tendency to mirror is overcome by habit and training. Indeed a tendency to mirror writing and persistence in reversals of letters which was apparent when some children were first examined had disappeared on later examination. It seems difficult to avoid the conclusion that training and habit had corrected this tendency. Training would appear to bear more fruitful results in the case of the child of average intelligence as examination of dull and mentally defective children revealed a high incidence of inconsistent handedness. In the present results the high percentage of children who were dull and who showed crosslaterality or mixed hand and eye, would support the contention that as one descends the mental scale, one finds children or individuals who are less trainable.

With age the difference between the hands was seen in the amount of skill and accuracy shown on the Performance Tests. In most cases the right hand was more dextrous and showed superior results to the left. Yet if the change in dexterity is solely explained by practice it is difficult to understand why the left hand could not improve equally

well with practice and thus produce individuals who are virtually ambidextrous. Ambidexterity was not found to be prevalent in the groups, thus other causes must be sought to explain the differences.

The eyedness, or the selection of one or the other eye when the child was compelled to use one as in the eye tests, is not so susceptible to training as the hand. As with the latter the highest percentage frequency was found on the right side or for the right eye. The problem of the comparative acuity of the two eyes should not be confused with that of ocular dominance in sighting although a tempting assumption to make is that the more acute eye will be the sighting eye. This has not been found from previous research. Hand and eye involve oculo-motor adaptation and therefore in training, factors of visual perception and spatial orientation become important.

The visual function permits the identification and location of objects. Identification implies recognition of forms and sizes independently of position and distance. The area responsible for autonomous pattern vision is the visual cortex which receives messages from the photoreceptor neurons, intervening bipolar cells and ganglion cells. Although rods and cones in the eye constitute two distinct types of receptor cells their connections with bipolar and horizontal cells do not indicate from research that they form two distinct systems. Thus it would appear that the activities of rods and cones are closely related in the

visual functions. Furthermore in moving from the fovea or central visual area of the eye to the periphery one finds a predominance of cones to one of rods and a change from point-to-point to diffuse synaptic connections. The two optic nerves, one from each eye meet in the optic chiasma at the base of the brain where in animals they cross and end up in opposite sides of the brain from the eye of their origin. This anatomical arrangement does not hold for the higher mammals as the fibres from the more lateral parts of the retina remain uncrossed. Thus the halfretinae are projected into the homolateral hemisphere but because of the retinal invdrsion it is on the left hemisphere that the right visual field is projected. From this arrangement it is apparent that a predominantly left eyed child will show fibres terminating to an extent in the right hemisphere which is considered by some to be the minor hemisphere while the right eyed dominant will show fibres terminating in the left or major hemisphere for language functions together with lateral fibres to the left and right sides of the brain respectively. Eye dominance as a single unitary factor does not therefore exist as the motor functions of the two eyes are controlled by both hemispheres. It may be more true to say that the motor function of the dominant eye is controlled by the strength of motor and muscular development. Strength of eye dominance may thus be governed by the motor strength or dominance of the appropriate hemisphere. As children are trained mainly in right hand usage then the motor

functions of the left hemisphere may tend to receive a stronger bias which in turn reinforces the tendency to right eyed dominance. Higher percentages of right eyedness were found when compared with left eye preference. This will therefore differ from the visual acuity of the eye which in practice, refers to the discrimination of visual objects, i.e. the smallest object the eye can see.

While visual acuity is basic to perception of shape and form yet the problem of discrimination and orientation is further involved in pattern vision, thus good visual acuity does not necessarily imply good pattern perception. In the groups of children studied therefore, something more than basic visual acuity was involved in their performances of pattern perception in the Van Riper test. Closely associated with the elementary aspects of visual experience are the motor nuclei of the brain stem which control eye movements and motor aspects of adjustment of the head and body. Visual perception involves the spatial distribution of light on the retina but when such a distribution changes in one direction or another in time, then perception of movement emerges.

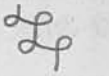
The problem of visual perception has received much attention in the past, particularly with reference to reading and eye movements in reading. While this may form a limited expression of it, studies nevertheless

have revealed how highly complex the process is. Approaches to the problem have been made through a study of the time necessary for light to fall upon the retina in order that sight may take place, through studies of the range of distinct vision and visual defects. The range of distinct vision involves the question of whether there are any physiological limits to perception or whether our perception of space is innate and inherent in the arrangement of the nervous system or whether it is acquired through experience. This is important for training purposes. Further, problems of perception involve the amount of material which may be comprehended in a single act of perception or what is termed the span of perception, a problem frequently attacked by means of the tachistoscope. The limit of perception varies under different conditions as previous experience and familiarity with material would appear to aid in establishing longer spans of perception. Further the limit of perception may depend upon maturity; thus work carried out on adults may not apply to children. Work on the span of perception in reading has shown that there is a continued increase throughout the school years of the child, the end result being a combination of training, experience and familiarity with language forms. This is in agreement with the general developmental picture of mental and physical maturity with the trend towards self consistency shown by the growing child. If it appears that there is an increase in the

perceptive span with increase in years, is perception wholly a learned response as empirical theory asserts, or does it develop along with maturation having an inherited basis as upholders of nativism assert? The evidence gained from results of pattern perception on the Van Riper would tend to modify the extremes of both theories and support the view that perception has a partly innate, partly learned organisation. In the Van Riper test three patterns were presented to the children, visual, script and kinaesthetic. While complications of motor adaptation inevitably enter the picture yet factors of identity and experience seemed at once apparent in a general consideration of the three patterns. The visual stimulus was totally unfamiliar to the children and appeared to present an obvious degree of difficulty as many children were unable to produce the entire pattern with both hands. While this could also be attributed to the difficulty of using both hands simultaneously observation of the behaviour of the children while drawing the pattern indicated that some were consciously trying to learn it. This degree of difficulty was not present with the auditory stimulus. The pattern of the word given was familiar to all of the children and it appeared that this prior knowledge and experience aided the recognition in that every child was able to write the word. With the kinaesthetic pattern, visual stimulus was excluded as the eyes of the children

were bandaged while learning the figure, yet the formation of an inner concept of what they were drawing appeared to aid in learning. After the pattern was completed the groups were asked to state what they imagined they had been drawing. The children who had carried a visual image of some familiar figure or gestalt were also the children who completed the pattern learning in the shortest time. Non-sensory factors therefore become important in kinaesthetic learning either as aids or hindrences to performance and the identity of a figure or the ease with which spontaneous association can be evoked as a result, greatly assist the learning.

The fact that there was less automatic recognition of the visual pattern tends to support a role of learning in perception. The visual pattern was not recognised and drawn in totality by all the children. Obviously the maturity and learning levels of the groups were involved but a qualitative estimate of their results showed the influence of eye movement and hand training in those children who successfully completed the pattern. Many of the children who were classed as partial mirrorers in the visual aspect of the test showed strong sinistral tendencies and were left eyed dominants. The orientation of the eye may thus be revealed in a spontaneous tendency to draw the figure continuously to the left. As a result the top half of the visual pattern was mirrored while the bottom half though correctly drawn maintained the

sinistral direction from right to left thus  .
Conversely, many of the righteyed children showed strong orientation from left to right. They therefore commenced by drawing the top half of the pattern correctly but mirrored the bottom part of the pattern yet maintained direction towards the right thus  . Thus while eye movement may influence direction initially the motor function of the hand exerts its pressure which with children tends to show the influence of training to the right. Yet the direction and nature of mirroring tendencies greatly suggest strong biological determinants in laterality. Yet if the eye only is accepted as the leading factor in guiding the hand, a conclusion would be reached that only the cases of mixed hand and eyeof lefthand righteyedness should tend to draw the pattern correctly, while cases of righthand and lefteyedness would draw the mirrored counterpart. This was true only in some instances as the cases of mixed hand and eye of both types were prone to mirror the pattern, as were the sinistrals and dextrals. Obviously then the eye determinants become inseparable from the action of the motor factors and both act together as a unit. The presence of mirrored patterns drawn with one hand and patterns as in normal vision drawn with the other, would lend support to a partial equipotentiality doctrine but the influence of the eye in extending direction to the left or right in the cases of partial mirroring would

likewise indicate that all parts of the retina are not trained in the same way. Peripheral and central vision are not therefore one and the same visual habit. Yet while the anatomical arrangement of the visual system may be partly responsible the apparent effect of hand training likewise is present and thus learning and training complicate the picture. The motor organisation in itself cannot explain the organisation of perception, yet it has an essential role and if the motor function of the eye is linked with the motor function of the hand then one might argue that training the hand to move in one direction should automatically train the eye in the same direction. Yet no significance was found in the data in the examination of the effect of the eye or the hand on achievement. Indeed it seemed impossible to say which had the greater effect. Yet children who showed consistency of hand and eye appeared to be achieving at a higher rate than those who were mixed in hand and eye. A partial explanation may be in the lack of integration of the motor system, which training may tend to exaggerate, particularly with crosslaterals. With pure dextrals or sinistrals training may tend to reinforce this integration. In studies of reading, investigators have proceeded on the assumption that automatic recognition becomes necessary or proficiency is gained by recognising the form as a whole. Such ability can be developed through practice. Observation of the results of a strange visual pattern on the varying

groups revealed a variation in the capacity to apprehend the total figure. What advantage therefore does a child possess who shows a longer span of perception? This involves the question of the use of peripheral vision. The peripheral portions of the field of vision are at a disadvantage in comparison with the area of central vision as the discriminative functions of the peripheral regions of the retina are on the whole practically non-existent. The variations perceived have only the value of a warning and entail a displacement of attention in correlation with a movement of the eyes. Thus the resolving power is maximal in the fovea and diminishes considerably towards the periphery while conversely the capacity for spatial summation increases in analagous proportions. Experiments have shown that peripheral stimulation of the visual cortex can control eye movement, thus movement will be in the direction of the light stimulation, producing such peripheral activity. It may be therefore that the peripheral field has a preparatory and anticipatory effect. This may be particularly obvious in scanning print which involves the fixation of points in a straight line, such that more rapid succession of movement is allowed on either side of a fixated point in either direction to right or left, which may compensate for the loss of breadth of clear perception entailed by the presence of these marginal impressions. A predominantly lefteyed child with sinistral orientation from right to left may thus show a strong tendency to absorb marginal impressions more quickly on the left side of the

visual field. This influence of peripheral vision with orientation will be most obvious in trained skills such as reading. With the lefteyed more regressive movements are thus made in order to follow artificial print and due to this interference rate of reading and perceptive span may be slowed down. A higher level of attention is required in order to inhibit the prefixational stimulation, hence the lefteyed child may be consuming more energy in an attempt to read at the rate of the righteyed. This effort may be successful as found in the data, the lefteyed were achieving as well as the righteyed but the effort may result in more ready fatigue, greater distractibility and general instability. It was of interest in a consideration of temperamental characteristics that the children of sinistral expression showed marked tendency to instability and to anxiety. Further these groups of children in the execution of the patterns showed mirror and reversal tendencies analagous to regressive movements in reading. In writing the script pattern many children reversed individual letters while maintaining a left to right orientation. In learning the kinaesthetic pattern many regressive movements were made with the stylus before a clockwise or anticlockwise direction was adopted. It is of interest that the lefthanded children learned the pattern through movement in an anticlockwise direction while the righthanded children followed a clockwise direction. Absolute spatial position appears unrelated to perception

in young children and mirror tendencies with inversion of figures offer no great difficulty to them but the present group of children were of sufficient age that maturational determinants together with training would appear to have established closer integration of such factors, although not completely, while recognising at the same time that qualitative differences in material make for differences in perception. Thus in performing the kinaesthetic pattern the close co-ordination of sensori-motor process was observed. The kinaesthetic impulse evoked a phenomenon in consciousness only after the movement had taken place, yet every movement occasioned a new sensory impulse in the brain centres which in turn contributed to the motor process. Strictly speaking no purely motor or purely sensory acquisitions exist but learning and development involve the progressive synthesis of both. In the adult, synthesis is well established but with children, learning and training are contributing their influence from infancy onwards.

Thus in conforming to a righthanded world children of marked sinistral orientation and those with mixed hand and eye or crosslaterals, in factors of visual perception and spatial orientation would appear to adapt themselves at the expense of much greater nervous energy than those children whose natural orientation is facilitated by training.

## Chapter 20.

## Laterality - Growth and Maturation.

Growth can be considered as development through maturation and development through learning. The former is dependent on the inherited characteristics of the individual although influenced by the environment, while the latter implies a change in ability or achievement due to definite individual activities. In a sense the environment governs the individual from the moment of conception, yet embryonic development is influenced by a different environment when compared with the period of infancy and the environment at that stage. The surroundings of the embryo are constant and external conditions influence only in the process of growth and maturation. In the post embryonic period the environment exercises a specific influence such that development tends to be a process of 'acquisition' which is learned. Thus it is true to say that certain stages of development are reached after learning has been added to growth and maturation. Inheritance and environment are interwoven and these opposing factors are present in every individual. It becomes an increasingly complex problem to decide what part of any performance may be acquired and what part may be inherited. In order to be effective, maturation requires stimulation through the functioning of the act itself, thus to a certain extent, capacities are controlled by laws inherent in the organism.

Yet the abilities of an individual are determined by his experiences and achievements. Thus the efficiency of higher species over lower cannot be reached or maintained purely through growth and maturation alone.

Most patterns of behaviour can be divided into categories of locomotor and manipulative. In the former, the individual moves about, while in the latter aspect of behaviour, objects are moved about in the environment by the individual. Thus hand and eye skill form a pattern of manipulative ability which is a specialised ability and which occurs later in evolution. Likewise with 'eye' manipulation. A fine degree of progressive co-ordination develops as ascent is made in the mammalian series. Man's dominant position in the animal world rests therefore mainly on his ability to make sounds and gestures in communication and on the skill which he has developed in the use of his hands. His laterality or his relationship of hand and eye has thus determined to a certain extent his efficiency in living. This efficiency will therefore depend on the continuing ability man shows in putting to skilful use, structures which may be innately determined and yet structures which respond to training. While classic experiments such as the 'chick-pecking' may tend to support maturation, yet the acquisition of hand skills becomes bound up with the learning capacity of the child in the sense that sustained training will lead to more efficient performance. Thus the final answer of learned activity or maturation is still

uncertain.

In intelligent behaviour these opposing factors of inheritance and learning or achievement are observed. An innate potential or capacity determines the limits of development while the performance or functioning of this inheritance reaches a level designated as average performance for the individual at various stages of growth. The latter aspect is frequently characterised as the intelligence of the individual whereas in fact it might be more true to regard achievement or performance as the effects of experience or environment on innate potential. In considering the intelligence levels of the subgroups in the present study, it was obvious that the Retarded Group were of poorer innate capacity than the Normal or Twin Groups, as the former entered the dull category while the Normal and Twin approximated to the average. These levels may be indicative of maturational development proceeding at different rates, more slowly in the case of the dull group. Their performance in achievement tests and in tests of motor skill was likewise below the levels of the groups at average grading and in relation to their poorer capacity. Although no significance was established with the laterality of the groups and their intelligence levels, it would seem evident that children of quicker growth or more maturity should show a tendency to greater consistency and refinement in their co-ordination processes. This was indeed found from the data. A lack of dominance

or less established dominance characterised the immature child. The greatest proportion of crosslaterality was found in the dull group, of lower mental age than either the Normal or Twin Groups. The lower level of maturation, with accompanying lack of dominance as exhibited in oculo-motor activity supports a hypothesis of growth and maturation being important factors in laterality. Yet the longer time taken to learn the kinaesthetic pattern together with the poorer scores of the dull children in e.g. the Performance tests when compared with the scores of the other two groups also reveals the poor skill and slower learning capacity of this group. The relationship of laterality to temperamental characteristics also supports the idea that children of maturer development show more consistent dominance and greater stability than those of younger or more immature level. Learning therefore proceeds with maturation and is likewise dependent on phylogenetic level for rate of learning in infancy would appear to be in inverse ratio to length of time for physical maturation.

Together with this development in refinement of co-ordination changes in the nervous system take place such that locomotor patterns come to depend more and more on the cerebral cortex. This has been observed from physiological and neurological experiments where fatal interference with locomotor abilities has not been proved after removal of the cerebral cortex in dogs and cats.

This state of affairs does not however exist for man as without a cortex man is unable to stand or walk. Therefore much more dependence of locomotion on the cortex is present.

As the nervous system grows, differentiates and establishes connections, it provides the majority of the reaction patterns required in the first few months of an infant's life. Yet this is also a time of learning. In human infancy learning is much slower than learning in invertebrates, but mature animals unlike mature human beings are unable to learn complex relationships. It is dubious if learning in animals is influenced by transfer or insight. Timing of maturation with characteristic reaction patterns is peculiar to each species and in general is characteristic of the needs of the animal. First human learning, is in a sense biological learning and serves the needs of the infant. The development which takes place with later learning proceeds by a gradual building from previous experience and without the participation of attention and memory learning does not take place. Thus fundamental to all learning is perception as no memory can be formed of what has not been perceived. Likewise fundamental to perception are factors of visual experience in retinal stimulation and in spatial orientation. Thus broadly speaking sensori-motor factors underlie all learning particularly in childhood. Oculo-motor adaptation thus becomes of prime importance. This

adaptation will be facilitated by the speed with which specific movements are learned yet as found in the data training and the environment apart from maturation, influence these factors considerably.

In man the cerebral cortex is necessary to carry out co-ordinated movements with the so-called motor area or precentral gyrus being the most important, but overlapping of executive functions with other areas is also present. Hebb, in his Organisation of Behaviour, bases part of his theory on this feature. The overlapping of executive functions is apparent in the observation of cases with brain injury. If the entire motor area is removed together with the overlapping areas, complete paralysis will result in the individual, but if injury is confined to some portion of the 'executive' areas, there results profound paralysis at first with gradual recovery.

According to the degree of recovery in animals and man has been established from experiment, the increasing corticalisation of motor functions. It is of interest that gross motor abilities return first as in locomotor activity, but much slower to return are the manipulative abilities e.g. as in writing, using a pencil. Thus there is evidence of increasing specialisation in motor function.

Studies by clinicians all point to the unitary character of apparently complex cortical functions. Loss of function in brain injury and extirpation experiment appears to be global. This mass action and multiple

integration of the brain systems may help to throw light on the complex problem of laterality. At an early age children appear to show bimanual activity, the right hand alternating with the left. There is no specific specialisation shown in handedness until later. If a theory of cerebral hemispherical dominance is accepted where the handedness is dependent on a dominant hemisphere and where the hemisphere is likewise determined by the preferred hand, then with young children no dominance is established and each hemisphere tends to act in complementary fashion as first one hand is used and then the other. At this stage motor action results in gross movement and reactions which are more precise and refined do not appear until a later stage in development, particularly when the child learns to read and write so that it would seem that motor activity unrelated to language or verbal facility can involve either hemisphere equally. Both hemispheres appear interdependent in learning skills. The difficulty arises when language is introduced as the maturation of the individual together with training has led to the predominance of one or other hand, usually the right hand with apparent predominance or development of one of the hemispheres - the left for the right hand and vice versa. Investigations on aphasic patients have likewise revealed that the dominant hemisphere or the major hemisphere is the one most commonly involved in language difficulties, as injury to the minor hemisphere causes little relative difficulty with language

skills while injury to the major side creates various manifestations of the aphasias. The hemispheres of the brain in early development work in an interdependent fashion and complementary pattern, therefore, with a later assumption of hemispherical rivalry. If one agrees that the human being is consciously or subconsciously striving towards greatest equilibrium mentally and physically, then a theory of hemispherical rivalry would not contribute to stability which is the ultimate aim of the organism. The difference in the direction of the laterality from gross movement to refined specialisation is affected by the acquisition of language skills. Yet a point which is not frequently stressed is that a considerable degree of linguistic comprehension precedes the ability to speak as children will frequently nod their head to agree with a statement or question even though no vocal response is given. Thus the intelligence of the child and its level of comprehension of the environment enter the picture in language skills. How then, is it possible that in only one part of the brain language assimilation should be stored or concentrated, namely in the major hemisphere? One might argue as has been postulated by Sinclair that myelin development proceeds with maturation and therefore that the left hemisphere tends to become functionally more important than the right due to the greater stimuli increasing myelin differentiation arising from greater use of the right hand in the majority of children but this would not explain

why certain children retain a tendency to use the left hand nor can one argue that myelin functionalism can decide such intricate operations as memory or thought processes etc. Language involves conceptual generalisations or general intelligence and it seems impossible to consider this as functioning with greater emphasis from one hemisphere only. Results in the study revealed no significance in tests of reading and spelling between right and lefthanded children. If all language function depended critically on hemispherical dominance one would expect an advantage to be found with righthanded children. It has been claimed that specialisation leads to the dominance of one hemisphere, yet anatomical research has found no physiological superiority of one side over the other. Indeed the work of K. Smith in separating the commissural fibres forming the corpus callosum and finding no great bilateral differences for laterality in the hemispheres, would suggest that laterality is rather a function of the integrative action of the entire cortex and that learning plays a major part. The explanation may lie in a theory of 'equipotentiality'.

In considering bilateral organisation in the two sides of the brain the motor areas and the pyramidal system are almost entirely crossed but bilateral overlap is present, such that more rapid recovery from a lesion is apparent on one side if the corresponding area on the other side is intact than if it is removed also. Thus the executive functions are not entirely segregated. These aspects

led Lashley to formulate his term 'equipotentiality' which he designated as 'the apparent capacity of any intact part of a functional area to carry out with or without reduction in efficiency, the functions which are lost by destruction of the whole'. This capacity however, varies from one area to another and with the character of the functions involved, being possibly more involved for complex functions than for simple sensitivity or motor co-ordination. Thus a law of 'mass action' prevails such that the efficiency of performance of an entire complex function may be reduced in proportion to the extent of brain injury within an area, whose parts are not more specialised for one component of the function than for another. Particularly with motor inco-ordinations, symptoms may result from disturbances in the functional equilibrium between centres, although no tissue essential to the performance of the disturbed activities is directly involved. Hebb has expanded and elaborated on this fact in his idea of a 'cell assembly' and elaborate phase cycles delivering facilitation to other such systems and usually having a specific motor facilitation.

If then, extirpation of the cortex concerned with movement takes place, followed by recovery from paralysis or equipotentiality of function operates, how does this take place? It would appear that a process of compensation is operating. When injury to the brain occurs at an early age a reorganisation of brain function takes place. This

is greatest in the early stages of life such that parts of the cortical motor system remaining are responsible for the reorganisation. The recovery of motor functions seems then to depend upon remnants of the motor system remaining intact.

A similar situation exists with vision as with areas for movement. From experiments done by Minkowski with destruction of the area striata and the four quadrants of the retina on the occipital cortex, it was found that unless the entire cortical field corresponding to a retinal quadrant was destroyed, the defects were not permanent. Thus in both dog and man there appears some equipotentiality of function within each cortical field representing a quadrant of the retina. Further experimental work on pigeons by Levine has established this fact.

The question which is still unsettled is whether this equipotentiality is learned or innate? Does transfer or generalisation result from intensive training or is it a property of the organism?

The lack of significance between the levels of intelligence and the laterality characteristics of the groups is in agreement with the process of learning capacity changing with growth, as a conceptual development with meaning evolves from perceptual elements through association. A changed relationship thus develops between the central effects of separate stimuli and the motor response whose control is imbedded in the central activity. Learning thus progressively involves recombinations of familiar perceptions

and familiar patterns of movement. Yet to establish these underlying simple perceptions the child of mixed hand and eye co-ordination and the child whose natural motor tendency in handedness, is curbed or changed by training may experience much greater difficulty from the standpoint of visual and space perception. Crosslaterality may create extra difficulties for the achievement of smooth integration in motor and visual training and may thus be a hindrance to nervous integration. Yet once the properties of conceptual learning are established visual, motor, or spatial clues may be disturbed yet the learning persists. The presence of visual images and concepts in kinaesthetic learning, after the eyes were bandaged appeared to support this. Earlier learning was operating and effective. The persistence of conceptual learning independently of the sensory and motor elements which are involved at an early stage, has been found present in cases of cerebral injury at early and late stages of development. The effects of motor sensations and habits are anatomically diffuse and interlaced in the same gross cerebral tissue thus both hemispheres would appear to be involved. The persistance of conceptual learning independently of the sensory and motor elements involved implies the acceptance of autonomous central activity which selects or guides the response.

Yet the fact that children growing up in a righthanded environment stubbornly persist in their lefthandedness strongly indicates the existence of a genuine organic and

maturational basis of laterality as opposed to 'force of habit or training'. Observations in the twin study where one of the pair was right dominant and the other left dominant likewise support an organic determinant of lateral dominance.

Although the two homologous structures such as feet, hands or cerebral hemispheres are corresponding structures in the body they are reversed symmetrically, one being the mirrored counterpart of the other. Thus it has been held that training the hand in one direction likewise creates conditions whereby the other hand shows a tendency to movement in the opposite direction. Thus mirror writing and a tendency to right to left mirror perception have been held to be normal sinistral expressions. When children are allowed to write naturally with the left hand and when they are completely 'sinistral' no difficulty arises from the point of view of dominance. Likewise with pure dextral children. The inhibitory potentialities of the hemispheres tend to subordinate the activities of the contralateral side, thus one emerges dominant. It is when children who show crosslaterality are studied that there emerges a conflict of tendencies to perform an action and while this may be overcome by training and by the learning capacity of the child, it is overcome by an upset to the stability of the nervous system. As results show it may be an accompaniment to instability of the central nervous system. It is a handicap to the equilibrium of the most highly integrated functions, but a handicap which may be overcome when present in an individual with a sufficient resistance to or tolerance for this potential cause of nervous disorder.

## Chapter 21.

### Laterality - Neurological and Constitutional Factors.

The assumption of an organic basis for Laterality would indicate that failure and resistance might meet attempts to change the co-ordination of hand and eye. The trend of resistance characteristics as found in the data would support this contention. Yet the problem of Laterality with its resistances could be considered from the standpoint of secondary accompaniment to unstable temperament and reaction which at times might be considered quasi-neurotic. Cortical excitation therefore requires examination in this light.

Recent discovery, that rhythmic electrical impulses arise spontaneously and continuously in the central nervous system and that these potential waves are signs of excitation processes within central neurons, contributes much of importance in an understanding of behaviour. The central neuron may thus be in a state of centrally maintained activity and independent of afferent stimuli. The actual mechanism of excitation might be explained as an electrical change similar to that due to polarization by a current and electrical signs of cortical activity can be observed in the technique of 'electroencephalography'. In ontogenetic development centrally initiated discharges may appear first also as observations on chick embryo, have established movements appearing before the completion of afferent-efferent

neural connections. In man cortical potentials would appear to occur with greater amplitude and regularity, with a minimum of stimulation. Thus it has been postulated that it is a characteristic of certain central neurons to discharge periodically, an autonomous central activity.

The characteristics of these excitability changes among the neurons differ. Changes take place in the individual nerve fibre but as the nervous system is composed of millions of neurons whose fibres lie side by side, it is important to consider how one neuron initiates impulses in adjacent neurons. The interlacing of the neurons creates the functional junctures or synapses which, because of their shape can build up a sizable electrotonic potential and result in synaptic summation. This synaptic summation is a form of spatial summation or the summing of two stimuli at different places in the body. A further important property of the myriads of neurons in the central nervous system is the recurrent nervous circuit where impulses set up in one neuron eventually find their way back to the same neuron or travel in a circle. A consequence of this is that reverberation set up in the network can go on for a long time. Finally a further important property of the recurrent nervous circuit is temporal summation when the effects of two stimuli separated briefly in time appear to summate. This is not so simple a phenomenon as would appear at first consideration and may be related to the reverberatory circuits.

To what extent the autonomous activity of cortical

cells is dependent on the functional reverberating circuits and to what extent it is dependent on the spontaneous rhythmic properties of the single neuron cannot be decided in the present stage of research.

By mutual facilitation of small groups of cells synchronisation may take place when they are not caused to act independently, but when the activity of a given region is increased by stimulation it becomes the pacemaker from which waves are conducted in all directions to involve more and more of adjacent cortical tissue and thus a form of irradiation of excitatory effects is spread in the cortex. Time factors thus become important in a consideration of direction of conduction. The high degree of synchronisation often found over bilaterally homologous regions might suggest subcortical pacemakers as it has been shown from experiments in physiology that the same frequencies of spontaneous rhythm may be observed in both cortical and subcortical centres of the visual system in e.g. the cat. Although present knowledge does not permit definite conclusions in regard either to the amount or the precise nature of cortical activity, yet a remarkable constancy of frequency in the 10 cycle alpha rhythm has been observed in mankind. These waves appear in rhythm with almost mechanical precision hour by hour and day by day. Thus its constancy under standard conditions is at least as great as any other known human rhythm.

In ontogenetic development it has been found that rhythmic alpha waves develop between the age of 3 and 6 months. This corresponds remarkably well with the age at which infants begin to show behavioural indications of visual perception. Studies with children have shown at an early age, random wave activity with progressive increase in frequency with an exponential relation to age up to about 15 years. In addition in children rhythm over the motor regions has been found before occipital rhythm was developed. This would correlate with the developmental sequences in behaviour of an earlier establishment of a common sensori-motor system compared with later visual perceptive systems and is in accord with histological evidence of structural maturation in these areas. Thus tentative relationship with structural growth and maturation can be found with progressive establishment of adult patterns of rhythm as the child develops and matures.

The relationship of these waves to stimulation indicates that their rhythm can be blocked by sensory stimulation. Blocked records have been found similar to that produced by autonomic tension or by stimuli producing a startle reaction, thus a chronic state of heightened cortical excitation may be involved. Changes in the time or tempo of the waves can likewise accompany emotional reactions. Thus individual differences found in brain wave records may be associated with emotional lability. Although

research has not proceeded sufficiently far to state cause and effect with any definiteness, yet the trend in brain wave study would indicate that alpha waves are more in evidence in the placid reposed individual and less apparent with active restless types. Those people whose minds are constantly active should not therefore show a great deal of alpha activity. Abnormal cortical systems tend to show an association with slow waves or delta waves but the question of which is cause and which is effect has not yet been settled. For the present brain waves have been found to differentiate more clearly in children than in adults, certain behaviour disorders, delinquency and emotional problems.

The most dramatic changes in spontaneous electrical activity of the cortex have been shows in epileptic disorders. The potential waves are not only changed in form, frequency and duration but the greatest change is in their amplitude. Epileptic children are likewise frequently found to be severe behaviour problems with deterioration showing more on the temperamental side than on the intellectual side although their intelligence also shows frequent deterioration. Their behaviour is also often characterised by irritability, aggression, lack of concentration, restlessness and general instability. Many of these temperamental characteristics, although possibly to lesser degree, were found among the children in the present study. It is feasible therefore to

surmise how much irregular brain wave activity might be present in our groups of children who show lack of integration of the nervous mechanism. If alpha waves come from many neurons pulsing in step then a link is postulated with co-ordination and synthesis. Whatsoever is unco-ordinated or lacking synthesis in the system may tend to create impulses irregularly scattered in time and so produce irregularity in wave pattern. Emotional reaction may therefore be associated with disruption of cortical neuronic timing. Significant relationship of laterality to temperamental characteristics was noted in the data where greater instability was observed with children who showed mixed hand and eye compared with children who showed coincidence of hand and eye. The crosslateral children in each group of Normal, Retarded and Twins showed much more tendency to nervous instability, delinquency anxiety and neuroticism. Likewise boys showed these characteristics more frequently than girls. One is therefore left to cogitate on whether laterality may be indirectly associated with heightened cortical excitation, in the link with temperamental factors.

It would appear surprising if the normal alpha activity found over various regions of the cortex, did not bear some relationship to cortico-fugal impulses in the peripheral efferent system. Thus future research may show closer links of wave characteristics to action potential of muscles and galvanic skin response and their total

relationship to personality disorders. In visual reaction time experiments, cortical response in the E.E.G. has been found to precede manual reaction. Thus cortical rhythms signalise excitatory processes which may be related definitely to nerve impulses reaching the final common path to the muscles. Is there therefore only a chance relationship in the fact that maximal frequency of voluntary movement in individuals has been found to be the same as that for the dominant rhythm of the E.E.G.? Mental effort as in problem solving has been found to depress the alpha rhythm, particularly if an element of emotional tension is present as in e.g. fear of a wrong solution, working under pressure. It is feasible therefore to postulate that as more resistance characteristics were present in boys of sinistral and crosslateral tendency, an association with muscular tension might be present. It may therefore be that in the stronger resistances made by boys, to attempt to interfere with natural co-ordination leads to heightened neuronic activity or increased cortical excitation with consequent blocking of natural rhythm. Adaptation of cortical rhythms may also be related to adaptation by the sense organs, although it would appear to be a predominantly central phenomenon. It may be therefore that inherent brain wave disturbance may be one factor in a behaviour disorder and if investigation could be made it is possible that crosslateral children and those where handedness has been changed may show more disrhythm

in brain wave with a tendency to slower wave associated with emotional instability.

If mental activity, intense thought or concentration have the effect of blocking alpha activity then one could assume that the dull group of children, because of lower level of intellect, should not show this tendency. It has been alleged however that with simple enough habits the dull or feebleminded learn approximately as fast as the normal. Thus there is no proof that the group of dull children are not working relatively as hard as the normal and bright. Indeed on achievement tests the dull group were the only children working to capacity. This group may thus be receiving stimulations equally intense as the normal group. The retarded group showed the greatest amount of crosslaterality and the highest incidence of instability. Thus brain wave activity with them should show a tendency to slow waves which are likewise associated with behaviour disturbance and instability as was greatly in evidence with this group..

The investigations of Raney 1938, with twin pairs, where he found that one twin showed a significantly larger relative difference between the two sides of the head, suggests that one twin was more strongly dominant. In the laterality analysis of twins in family pairs a high though non-significent relationship was found in the pure with cross comparison of older and younger pairs. The suggestion was that if one twin showed coincidence of hand and eye, the other would tend to show crosslaterality.

In terms of stability, one twin would be stable and the other show a tendency to instability. A purely subjective estimate made during actual test interviews with twins bore out this suggestion as one twin invariably appeared mature and stable while the other displayed behaviour which was erratic and unstable. This latter twin likewise showed weaker physique when observation of superficial characteristics was made. Thus the tendency in the twin family pair data would tend to support Raney's theory of cortical excitatory state. Furthermore the idea of instability being rdated to a lack of definite dominance is borne out in the data of the different groups and again suggests a quasi-neurotic reaction pattern. The presence of sinistrality and indefinite dominance in defectives and psychopathic individuals in relation to a slowing down of brain rhythm might suggest some common denominator in all these conditions and perhaps point to some growth depressing agent at work in the internal environment which causes a slowing down of the rate of spontaneous rhythm in the cells. When for study only complex mass effect of stimuli causing irradiation of activation throughout the cortex is possible at the present time, then relationships to complex aspects of behaviour can be inferred only. The underlying basis of much of this electrical activity is still very obscure but various characteristics of cortical potentials have however revealed from experiment, important functional neural correlates with certain aspects of behaviour and its

deviations.

Further research by psychologists whose leanings are to neurophysiology may yield in this field the necessary objective and quantitative measures required for future personality study.

## Chapter 22.

## Laterality - Heredity and Foetal Position.

In considering a doctrine of genetic determination an assumption is implied that no feature of a personality or individual is devoid of hereditary influences. Since genes enter into the production of every bodily cell it is not untenable that every structural characteristic should receive initial determination from them. Yet while every characteristic may be influenced in such a manner the outer environment may also exercise its influence and thus development and its orientation may depend to an extent on the exigencies of the physical and social environment. Thus the problem of the parts played by nature and nurture once again comes to the fore.

The influence of genetic factors has been studied in comparisons of twins: the main type of study being the co-twin control method. By this means, a pair of twins is studied where one is given specific training and the other no training. Differences and similarities on such types of investigations are interpreted in terms of a major effect of heredity or a major effect of environment.

As foetal position relates primarily to the unusual conditions in utero of twins, the present chapter will concern itself mainly with a consideration of laterality as related to heredity factors and foetal position in the twin group.

Studies of twins present evidence of almost universal acceptance that two types exist, identical and fraternal, or monozygotic and dizygotic. Proof of the existence of the two types of one egg and two egg twins rests on observation of twinning in other mammals, particularly the armadillo where subdivision from a one egg type has been noted and observed. Furthermore the fact that over one third of the more similar twins exhibit mirror imaging of asymmetrical characteristics, e.g. hand, hair whorl, palm print etc., has been accepted as explanatory of the fact, that such twins must be derived one from a right and one from a left half of a single embryo. Finally the existence of Siamese twins attached frequently by a common umbilical cord and who often exhibit reversed asymmetry of heart, stomach, liver etc., in one component of the pair appears to further support such a contention.

If this is so then one egg twins must have identical heredity and therefore will be of the same sex, while two egg twins may be the same or different sex. While it is usually supposed that the environment is the same for both types of twins, this does not necessarily follow. It becomes thus an extremely complex and difficult problem to classify twins with certainty as identical or non-identical.

Attempts have been made to classify twins as one or the other type, by the Foetal Membrane method and by the

Similarity Method. According to the former theory, obstetricians regard one egg twins as monochorionic and dizygotic twins as dichorionic, but it has been shown that when the two chorions are pressed together, they tend to fuse, and on occasions, may appear superficially as monochorionic. Thus, misleading reports may be made of supposedly one egg twins who are in reality, two egg twins. Membrane diagnosis likewise fails to differentiate between the two kinds of twins as to modes of origin because one egg twins have been found, who are dichorial and who have two placenta. To the embryologist, this means that twinning may occur at a very early period, possibly prior to the trophoblast and inner cell mass stage, possibly during early cleavage.

According to the Similarity method, members of a pair of twins are compared with respect to numerous physical characteristics, determined by heredity. As the number of characteristics increases arithmetically so proceeds geometrically the chances of any two siblings not being alike on all the characteristics. The underlying assumption is that one egg twins have identical heredity whereas two egg twins may differ in the same way as do siblings.

In the present study there was no possible way of obtaining such data which would point with reliability to a twin being identical or non-identical as superficial physical characteristics were considered to be misleading. The most that could be attempted was to consider them as

being likesexed and unlike sexed. Obviously the latter can be grouped as fraternal twins while the former may or may not be identical. An analysis was therefore made of the twins in family pairs in terms of first born classified as the older, and second born classified as the younger twin.

In considering the incidence of sinistral expression in the twin group, support can be given to Rife's statement that a high percentage of lefthandedness characterises twins when compared with the single born, as the highest percentage of pure sinistral cases was found in the twin group.

If lefthandedness is explained as due to an asymmetry reversal mechanism in the process of embryological development, then differences in reversals between identical and non-identical twins should be apparent. Although the twins were not considered under the foregoing categories, percentages found for like and non-like sexed twins in this study, indicated a trend of stronger sinistrality among the likesexed when compared with the unlike sexed. Likewise higher percentages of reversed asymmetry where one twin showed right hand dominance and the other lefthand dominance, were found among the likesexed twins for both boy and girl twins respectively, than for fraternal twins. Thus, according to the criterion of reversed asymmetry being characteristic of identical twins these groups might be considered as such.

Although the presence of mirror imaging has been held to be confirmatory of one egg twinning, as left handedness is expressed nearly four times as frequently per zygote in identical then in fraternal twins, its absence does not deny monozygocity nor would left handedness in one of a pair of decidedly unlike twins indicate that they are monozygotic. If consideration is given to the high percentages of sinistrality among the fraternal twins it is obvious that these assumptions would not be tenable. Newman explains such differences as due to the twinning process and peculiar to that process.

According to a theory of separation associated in time with the establishment of the primordia of hand the twins in the likesexed groups must have separated early, as high percentages showed similar handedness. Yet why should twinnings, both separating before the primordia of hand, show much greater tendency to be two righthanders rather than two lefthanders? The percentage for all the twins where both twins showed righthandedness was 52.66% compared with 8% where both twins showed lefthandedness. In the present group chronological age and training factors may be a partial explanation of this difference.

An examination of the twin data according to categories of older and younger, did not yield significance with laterality. It was therefore impossible to assert that a first born twin would show any particular form of hand and

eye combination, when compared with the second born although a slight tendency for one twin to be coincident in hand and eye and the other to be mixed, was observed. It would seem therefore that a theory of handedness according to separation after or before the primordia of hand is established is difficult to justify.

Attempts have been made to explain the excess of lefthandedness among twins by the assumption that lefthanded fraternal twins are the survivors of triplets or quadruplets. Statistically this is not a feasible explanation as every fraternal pair should therefore contain a survivor of a monozygotic pair.

A further explanation has been advanced that the prenatal life of twins may predispose to lefthandedness more than that of the single born, in the fusion of fetal blood vessels and therefore the consequent inequalities of blood supply. It may be possible that early differences in vigour and vitality may be the result of minor inequality in the fetal blood supply of the twins resulting from an imbalance in the placental blood exchange, but it is difficult to view the tendency to sinistrality in this light. This placental anastomoses is peculiar only to identical twins, for there appear to be no known records of it for two egg twins and thus the high percentage of lefthanders in fraternal twins could not be explained by this fact.

It would appear that twinning and lefthandedness

might be genetically linked and that both therefore have a common genetic basis. Yet sinistrality cannot be considered as due wholly to the twinning process for high percentages of lefthandedness were also found in the group of dull children. A consideration of the background family constellations of both the dull and twin groups revealed that in many cases of lefthandedness, relatives in the family also displayed sinistrality. If a hereditary factor is operating then righthandedness would appear to act as the mendelian dominant and thus be more strongly perpetuated, while lefthandedness could be classed as the mendelian recessive. Yet there is no character of any organism which is not both inherited and acquired, in the sense of 'evoked response to the stimuli of the environment'.

The characters which an embryo produces during its development are in some way controlled as regards their ultimate quality by the genes which the embryo has inherited from its parents. But no abnormal characters in development will be produced if the external conditions to which it is exposed, are normal. Thus it could be argued that twinning and sinistrality may both be conditioned by factors which affect rate of embryological growth, in the inner cell environment and so render it abnormal. The power of 'regulation' in young embryos, makes unification of the component cells possible, so effecting behaviour as an organism. This power is

likewise determined from embryology by the rate at which the quantitative axial gradient of the egg has been translated at all its levels into the chemical and qualitative differentiation of organ-forming substances. Influences which affect the power of regulation or the organising centre, the most sensitive area, reduce its control over the embryo which may then separate into separate halves. Each part may then begin to grow independently and give rise to a pair of whole individuals. A principle of 'regulation' applies such that in the course of development a succession of qualitative restrictions are imposed on the developmental possibilities of the different parts of the egg. Modification of this regulation may be regarded as a growth depressing agent. It may be therefore that twinning is partly a result of a growth depressing cause in the environment and as the physiologically inferior half tends to be relatively depressed will therefore tend to show reversal more frequently. It may also be that growth rivalry is present in the two halves of an embryo such that the stronger region inhibits the weaker.

Thus abnormality in the environment may tend to produce factors of twinning with accompanying inferiorities and may explain the excess of sinistrality in both types of twins. An environmental theory extended to single children could be supported by the presence, as in the data, of a high percentage of lefthandedness in the dull group, which is one of immature children, developing at slower rate than

either the normal or twins. It has likewise been found that among cerebral palsied children lefthandedness is more than twice as common as among normal children. In the case of the latter types of children important factors in their physical handicap have been stated to be intra-uterine degenerative and toxic characters - a growth depressing agent.

Thus although a tendency to twinning and lefthandedness may run in families and be inherited characteristics, yet the results of the reactions on one another of the various parts which constitute the causal chain of developmental events are constantly conditioned by the internal and external environment.

If twinning is regarded as a biological inferiority and partially created by a growth depressing agent in the environment and if lefthandedness is genetically linked to twinning, some such theory might explain the high percentage of lefthanders in fraternal twins. It was found however that complete reversal or lateral dominance of hand and eye was not characteristic of each individual either of twins or single born and many children were found who showed only partial asymmetry or who were crosslateral. This feature appeared to be a part function of training. Similar percentages of partial asymmetry were found among the like sexed and fraternal twins. If twins are frequently derived through the bilateral fission of prospective right and left sides of an embryo, then one would expect as much difference

in character expression in the two partners of some identical pairs as occurs on the two sides of single individuals. Temperamental factors studied in Siamese twins have revealed in some cases great differences between the two individuals concerned. Complete asymmetry may not be found in every respect thus an individual not wholly reversed or unreversed results, or in other words an individual showing less integration. Newman takes it as proven from statistics that an amount of reversal rarely complete and frequently only slight, occurs as a concomitant of monozygotic twinning. Yet this incomplete reversal was found most frequently among the dull children and least in the present group of twins, therefore it would not seem to be a prerogative of twinning. Training revealed the shifthanded group thus such differences would appear to be the products of training and of the external postnatal environment.

No significant relationship was established with laterality and intelligence yet a frequent association with general instability was found in the twin group, such that twinning seemed to be associated with an effect on temperament. An inherited disposition was therefore postulated, linking twinning, sinistrality and general instability. Findings reported by Raney 1938, have indicated that in studying startle response in twins where tests of manual dominance were used, in every case the twin showing the larger startle response tended to be

crosslateral or lefthanded. In the present data it was found that more instability, more characteristics of anxiety and neurosis were present in the twins when compared with the normal group. The incidence of schizophrenia in twins together with the presence of dysrhythmia in the twin of an epileptic whether affected or not, would tend to support an inherited temperamental factor associated with twinning. Whether lack of integration of the nervous mechanism as reflected in twins and children showing mixed dominance or whether sinistral tendency in asymmetrical reversal of twins is a partial cause of the instability of temperament or merely a concomitant of an inherited disposition quasi-neurotic in type, is indeed difficult to state with finality.

## Triplets.

Included in the data was one set of triplets. They were all of the same sex being male. For interest the following table shows the intellectual gradings with achievement quotients on the educational tests, together with final laterality grading.

I.Q.s and A.Q.s of the Triplets.

| | 2nd I.Q. | 2nd A.Q. | Hand and Eye |
|---|---|---|---|
| A oldest | 61 | 98 | Ambi hand - lefteyed |
| B 2nd old. | 85 | 61 | LH / RE |
| C Youngest | 73 | 97 | RH / LE |

On temperament A was rated as being least dominant and most introverted while B was considered most dominant and most extraverted. C was likewise considered dominant and extraverted.

Physically they were small yet all were unlike in facial features and as frequently found in multiparity births had been premature as babies.

In terms of laterality B and C show complete asymmetrical reversals while A shows sinistral tendency of eye but indeterminate handedness. Intellectually A shows the weakest power while B and C both enter the dull grading. Yet all three are well below average intellectually. It is possible that these triplets may have been the result of two egg fertilisation with one egg twinning, B and C being the twins or they may have been of three egg type as they were dissimilar in physique. It seemed unlikely that they were identical in the sense of identical twins.

The presence of sinistrality in each of the triplets is interesting and lends support to the suggestion that triplets like twins may be biologically inferior. If

conditions in the internal environment such as growth depressing factors are at work then sinistral expression combined with lack of dominance or mixed dominance in laterality would appear to be associated factors.

## Chapter 23.

### Summary and Conclusion.

A study was made of the laterality characteristics of children who showed difficulty in assimilation of the basic skills in reading and spelling because of a well defined pattern of learning interference in directional confusions, reversal tendencies of letters and words, all of which are typical of so-called developmental aphasia.

An experimental group of over one thousand children was chosen for individual investigation and the sample included children from a normal school population, a group of twins and a sample of retarded and dull children.

The problem was to study the extent of the influence if any, in the language work of these children, of factors of laterality, which might cause interference in normal learning and to learn more of the incidence and nature of laterality generally.

In order to have a medium which would be satisfactorily uniform for a group of age range to 12 years, language attainment was measured in reading and spelling tests only.

The Accomplishment Quotient was used as a chief means of detecting the influence of factors other than low level of intelligence in creating educational retardation. In the distribution of Accomplishment Quotients, below 100,

a complete range of extraneous learning interference was present in varying degree from negligibly slight to extremely serious.

The whole involved primarily a comprehensive survey of the interplay of factors of intelligence and achievement in this situation in order to establish the incidence of retardation in the group with the degree of laterality interference present. The relative influence of laterality and of other factors operating to produce retardation has been considered.

The more general characters of the total group were considered first of all. It was found that the intelligence level of the group approximated to the average, with no significant difference present between the boys and girls. In the achievement tests however, the boys were found to be significantly poorer than the girls while the total group was working to only 87% of their capacity.

It was therefore established that retardation was present in the group. Only some 7% of the children showed no language problem in that work as measured in the educational tests was commensurate with ability. A significantly greater proportion of boys was found who appeared to show the impress of language interference outwith capacity while girls of higher intelligence showed poorer achievement educationally than girls of lower intellectual level.

Reasons for these differences were sought in a study of the laterality characteristics in the differing

groups of 770 of these children. The extent to which aphasic factors would be operating to cause learning interference were studied in relation to intelligence and achievement.

It seemed proved that laterality, in all the variations of hand, dextral, sinistral and crosslateral bore no significant relationship to the intelligence of the individual. This appeared true of the different types of children, dull, twin and normal.

Incidence of dominance revealed more coincidence of hand and eye in the normal and twin groups than in the group of dull children.

Although no significant sex difference was found in the laterality of the total group, more boys than girls revealed mixed dominance of hand and eye, or crosslaterality.

An analysis of the categories of hand and eye with performance in the educational tests of achievement, established no significance of laterality with achievement. Girls who showed coincidence of hand and eye appeared to be attaining at a higher level than those who were crosslateral, although this was not characteristic of the boys.

As differing combinations of hand and eye did not appear to be major causative factors of interference in intelligence or achievement, further investigation was made, to ascertain if any significant relationship

existed between laterality factors and temperament. An indirect influence might then be postulated through the temperamental link.

The trends in the examination of laterality with temperament pointed in all the groups to an association of sinistral tendency and crosslaterality with instability. Children who revealed coincidence of hand and eye showed more stable characteristics than those who were mixed in dominance. The boys as a group were found to show resistance characteristics and negative temperamental tendencies more than the girls and a significant sex difference was found in the Twin and Retarded groups.

One factor in the explanation of the poorer educational achievement of boys compared with girls, was therefore postulated in this link of laterality to temperament. Boys showed greater incidence of sinistral tendency than girls and more evidence of crosslaterality. By reason of greater associated instability and resistance characteristics therefore they might be subject to greater learning interference.

Conditions underlying and determining laterality were then considered in the light of four major approaches to the problem and an explanation sought for the multiplicity of trends in the data.

The theoretical consideration of laterality in the light of training, maturation, neurological and

heredity factors reveals how each aspect can influence oculo-motor co-ordination in the individual. Innate and external environment become artificial distinctions, for child or adult is governed by both in laterality, while the efficiency of the individual is largely determined by a proper balance and integration of the contributing aspects.

Facts of training, habit and custom in directing unilateral preference would appear to be irrefutable. The presence of shifthand cases in the data, who were innate lefthanders trained in righthand usage would point to the suggestion that the percentage of lefthanded people born so, is possibly much higher than estimations indicate, but training covers over natural tendency.

Yet while conformity to social custom would appear to be an important factor in hand selection the demands of the environment may tend to create temperamental difficulties for the constitutional lefthander in that resistances are raised and training may be only partially successful. A crosslateral child of righthand lefteye dominance may result from the effort of changing handedness in a purely sinistral child. A strong biological determinant of laterality would thus appear to be present. Interference with natural sinistral tendency in such a type should be approached with caution.

A consideration of maturation and growth factors shows that among the dull children the greater percentage

of mixed dominance cases found, may mean that constitutionally poor biological material tends to lack the maturational determinants of lateral dominance, or it may mean that dominance is a learned form of behaviour such that unstable and poorly integrated nervous mechanisms in these children are subject to greater handicap in establishing oculo-motor co-ordination patterns.

A consideration of temperamental factors from a neurological point of view would support a theory of heightened cortical excitation or a disruption of cortical neuronic timing. These conditions together with a slowing down of spontaneous rhythm in the cells, may be possibly more characteristic of the mixed dominance cases or where interference with natural hand selection has occurred.

Finally the trends of laterality as observed in the differing groups would suggest a genetic factor being present such that dextrality might be considered as a Mendelian dominant, while sinistrality might be the Mendelian recessive characteristic.

Yet in the twin group, the high incidence of sinistrality with a high percentage of mixed and indefinite dominance in the dull group would lend credence to the idea of some growth depressing agent being present in the early foetal environment and leading to biological inferiorities.

While much is still speculative it would seem proved

that laterality combinations of hand and eye do not influence intelligence. On the contrary as learning proceeds with maturation it is suggested that at an advanced and mature level of development specialisation of oculo-motor activity in refined and co-ordinated movements becomes a function of the integrative action of the entire cortex and that learning plays a major part in selecting and guiding the response.

Children likewise do not appear to be handicapped by combinations of hand and eye in educational achievement as measured on simple tests of basic skills. Yet there is reason to believe that educational results may be indirectly affected by laterality through negative temperamental characteristics which appear to be significantly associated with children showing crosslateral or sinistral tendency. These adverse influences may be most strongly operative or indeed initiated in the early years of school training yet their effects would appear to persist throughout the later childhood years. The present groups of children were studied at the close of their primary school period yet the trends and characteristics measured were definite and of significance.

Lefthandedness may be organically determined and attempts to change the constitutional inheritance may therefore meet with temperamental resistances yet from results of the preceding study, it may well be that an inherited instability of temperament is the important

factor associated with sinistral expression and secondary effects of mixed or indefinite dominance of hand-eye co-ordinations. Lack of muscular and nervous integration may therefore be one feature of a general imbalance or maladjustment in an individual of unstable personality.

Since at the present stage of our knowledge finality is not possible, further research in the field of temperament and personality is required before it can be established definitely to what extent laterality may be cause or effect of adjustment or maladjustment in an individual.

## Chapter 24.

### The Educational Approach to the Child.

As the present study was designed to learn more of the occurrence and manifestation of laterality in the child it is fitting to consider finally what application can be made of the results in the training of hand and eye co-ordination. If, as has been found in the data, almost 25% of children are trained in righthand skills although of strong natural sinistral tendency then it becomes incumbent on teachers and educators to ensure that early guidance will prevent confusion and increase the child's efficiency.

Hand training in the early years is largely a matter for parental guidance. Some children will very early appear to be settled in a strong righthand preference, particularly if the parents are righthanded, while other children may be clearly lefthanded by preference. Yet in many homes the child may receive no specific training and by school entrance age be indefinite or indeterminate in dominance. It becomes of importance therefore that parents and teachers should understand the significance of the correct early approach to this problem.

The study of laterality has revealed the multiplicity of factors involved, and its complexity should lend strength to the plea that the entire makeup of the child

be considered in its physical, intellectual and emotional aspects. The earliest training will obviously be a form of habit conditioning through imitation with strong suggestion. Yet a consideration of the temperamental aspects in the data reveals how important will be the emotional reactions to training, particularly in the case of boys. It is a commonplace to suggest that in the beginning training should be associated with pleasurable activity such that no resistance and negative results will accrue. If training is associated with punishment and harsh coercion then the attendant emotional difficulties will block satisfactory results.

The varying intellectual levels studied suggest that more difficulty in training will be found with the dull or slower maturing child and more patience will be required to effect the establishment of smooth oculo-motor co-ordination. Training by non-verbal methods and imitation may prove quicker than verbal injunction as the level of comprehension is poorer and the child requires concrete aids in learning. Yet while it is desirable to train towards consistency and dominance in hand lead, it is equally essential that those who are training, whether teacher or parent, should be united in their views on which hand should be trained.

By school age, the task of the teacher will be to strengthen the dominant lead where established or to encourage dominance in the indeterminate hander.

As results in the data suggest that a pure sinistral can achieve at as high a level as a pure dextral, then little harm can be done by recognising that a child is lefthanded and strengthening the lead. The important point to establish would seem to be, which hand is more trainable for skills?

The question of changing the handedness of the child should be viewed in the light of the temperament. Complications in delicate neuro-muscular habits can be set up and emotional upset created in a young child by unwise changing methods which in an older child may not be so apparent. Yet the high percentage of crosslaterals and shifted sinistrals with negative temperamental characteristics in the present group of children who had reached the end of their primary stage of schooling, suggests that the effects of imperfectly shifted hand can be lasting. As handedness may vary in different activities, a decision to change the hand or not must be made only after consideration of the hand activity in several skills, if the developmental history of the child is in agreement with the hand preferences shown and if the temperamental makeup suggests stability. The existing strength of dominance in the child will indicate whether a change will be easily and successfully made or otherwise.

Training children to shift hand, usually from left to right, requires a high degree of psychological insight into the processes involved, particularly the

aspects of temperament, if resistance is to be avoided. A method of gradual unobtrusive training which reveals patient sympathetic encouragement on the part of the teacher will gradually help a child to gain success through his own efforts.

The most common unimanual skill which will be encountered is writing. It is frequently difficult for teachers who are themselves purely dextral to appreciate that a pure sinistral child must interpret modes of action on occasions from a reverse or sinistral pattern before translating them into a dextral pattern to which they must conform. Differences between dextrals and sinistrals of writing stroke, vision and posture are frequently ignored in a demand for uniformity. The muscular adjustment of the lefthander in writing is quite different from that of the righthander and produces much more ready strain and discomfort.

A further major disability lies in the visual perception of the lefthander. As he is unable to view what he has written a persistence of mirror writing is more frequently found with him.

Mirror writing can be overcome by the cultivation of greater visual control of writing as its persistence is due to learning by motor sense without visual observation. In learning the kinaesthetic pattern with eyes blindfolded, many sinistral children showed anti-clockwise direction as muscle feel was their main

guide. Thus sinistral types who practice writing from copy will be less likely to show reversals than those who rely on memory alone.

Writing associated with reading will likewise aid in establishing proper perceptual direction if meaningful content is present. Reversals in reading will yield to the general principle that training with simple comprehension will aid the perceptual process. Dull children will learn more slowly and show more reversals, as found in the data, but complications of low mentality, poor learning ability and comprehension, with poor word recognition and weak phonic synthesis will likewise contribute to the difficulty. Thus the reading assimilation of the sinistral child is rendered more difficult and further complicated by the tendency of the peripheral vision to fixate stimulations more readily in a reverse direction. Spelling disabilities are also found for similar reasons as in writing, in the spatial orientation and the perceptual processes of these children. Yet as established in the results, these tendencies can be overcome by training. Yet the training requires an understanding by the teacher or parent that the lefthander or crosslateral need suffer no severe handicap, either educationally or temperamentally if the 'whole' child is considered and if a wise application is made of the psychological knowledge of the underlying factors in laterality, factors both hereditarily and environmentally determined.

## BIBLIOGRAPHY


1. 1951 - Pupils with Mental or Educational Disabilities. Report of Advisory Council on Education in Scotland. H.M. Stationery Office, Edinburgh.

2. Adkins D.C. 1937 - The Effect of Practice on Intelligence Test Scores. J. Educ. Psych. Vol. XXVIII 1937.

3. Ames L.B. Supine Leg and Foot postures in the Human Infant in the First Year of Life. J. Genet. Psych. 1942 - 61, 87-107.

4. Ames L.B. Bilaterality. J. Genet. Psych. 1949 - 75.

5. Ballard P.B. Sinistrality and Speech. J. Exper. Ped. 1911/12 - 1, 298-310.

6. Berry R.J.A. Some Recent Advances in the Study of Brain as the Implement of Mind. Trans. Roy. Soc. Edinburgh. 1944.

7. Brain W.R. Speech and Handedness. The Lancet 1945. Vol.249, 837-841.

8. Bruce A. and Dawson J. Multiple Neuromata of the Central Nervous System: their structure and histogenesis. Trans. Roy. Soc. Edinburgh. Vol. XLVIII. Pt. 111. No. 27. 1913.

9. Bryngelson B. A Study of Laterality of Stutterers and Normals. J. Soc. Psych. 1940 - 11, 151-155.

10. Bryngelson B. and Clark T.B. Lefthandedness and Stuttering. J. Hered. 1933,24.

11. Burt C. The Backward Child. New York. MacMillan 1937.

12. Chamberlain H.D. The Inheritance of Lefthandedness. J. Hered. 1928, - 19, 557 - 559.

13. Chrysanthis K. Stammering and Handedness. Lancet 1947 - 252, 270 - 271.

14. Clark B. and Warren N. A Consideration of the Use of the Term Ocular Dominance. Amer. J. Optom. 1938 - 15.

15. Cooper W.E. and Bonney M.E. The Validity and Reliability of the Van Riper Critical Angle Board in diagnosing Handedness. J. App. Psych. 1942 - 26.

16. Cuff N.B. The Interpretation of Handedness. J. Exper. Psych. 1928 - 11, 27 - 39.

17. Cuff N.B. 1930. The Relation of Eyedness and Handedness to Psychopathic Tendencies. J. Gen. Psych. 1930 - 37, 530 - 536.

18. Cuff N.B. 1931. A Study of Eyedness and Handedness. J. Exper. Psych. 1931 - 14, 164 - 175.

19. Dahlberg S. 1926. Twin Births and Twins from an hereditary point of view. Stockholm 1926.

20. Daniels E.M. An Analysis of the Relation between Handedness and Stuttering with Special Reference to the Orton-Travis Theory of Cerebral Dominance. J. Speech Dis. 1940 - 5.

21. Dart C.E. 1938. Hand, Eye and Foot Preferences of 200 Mentally Subnormal Subjects compared with that of Normal Intelligence or above. J. Juv. Research. April 1938 - 22, 119 - 122.

22. Downey J.E. Dextrality Types and the Preschool Child. Twenty-Seventh Yearbook of the Nat. Soc. for Study of Educat. Part II 1928, 153 - 158

23. Downey J.E. Laterality of Function. Psychol. Bull. 1933 - 30, 109 - 142.

24. Dundson M.I. The Educability of Cerebral Palsied Children. Published by Nat. Found. for Educ. Research in England and Wales. Newnes Co. London.

25. Durost W.N. The Development of a Battery of Objective Group Tests of Manual Laterality with the Results of their Application to 1,300 Children. Genet. Psych. Monog. 1934 - 16, 225 - 335.

26. Ewing A. 1930. Aphasia in Children. Oxford Univ. Press.

27. Gates A.I. and Bond G. The Relation of Handedness, Eyesighting and Acuity Dominance to Reading. J. Educ. Psychol. 1936 Vol. 27, 450 - 456.

28. Gesell A. and Ames L.B. The Development of Handedness. J. Genet. Psychol. 1947 - 70, 155 - 175.

29. Gesell A. Infancy and Human Growth. New York. MacMillan 1928.

30. Gesell A. 1931. The Developmental Psychology of Twins - 'Handbook of Child Psychology' (C. Murchison, Ed.) Worcester Mass. Clark Univ. Press 1931.

31. Gesell A. The method of Co-twin control. Science 1942 - 95.

32. Gesell A. and Thomson H. Twins T. and C. from Infancy to Adolescence. A biogenetic study of individual differences by the method of co-twin control. Genet. Psych. Monog. 1941 - 24.

33. Giesecke M. 1936. The Genesis of Hand Preference. Monograph of the Society for Research in Child Dev. Vol. 1 - 5. Nat. Research Council, 1936.

34. Gilkey B.G. and Parr F.W. An Analysis of the Reversal Tendency of Fifty Selected Elementary School Pupils. J. Educ. Psych. 1944 - 35, 284 - 292.

35. Gordon H. Lefthandedness and Mirror Writing especially among Defective Children. Brain 1920 - 43, 313 - 368.

36. Haefner R. The Educational Significance of Lefthandedness. Teach. Coll. Contrib. to Educat. 1929 No. 360. New York. Bureau of Pubs. Columbia Univ.

36a. Head H. Aphasia and Kindred Disorders of Speech. 2 Vols. Cambridge Univ. Press. 1926.

37. 1947. Backward Pupils in Secondary Schools - Report of Headmasters' Assoc. and Headmistresses' Assoc. City of Glasgow 1947.

38. Hebb D.O. 1949. Organisation of Behaviour - Chapman and Hall Ltd. London. Wiley & Sons, New York.

39. Heinlein J.H. A Study of Dextrality in Children. J. Genetic. Psych. 1929. Vol. 36, 91 - 119.

40. Heinlein J.H. Preferential Manipulation in Children. Comp. Psych. Monog. 1930 - 7, 1 - 121.

41. Hildreth G. A School Survey of Eye-hand Dominance. J. App. Psych. 1945 - 29, 83 - 88.

42. Hildreth G. Manual Dominance in Nursery School Children. J. Genetic. Psych. 1948 - 72, 29 - 45.

43. Hildreth G. The Development and Training of Hand Dominance. J. Genet. Psych. 1949 - 75: 1950 - 76.

44. Hilgard E.R. and Marquis D.G. 1940. Conditioning and Learning. Appleton-Century-Crofts Inc. New York.

45. Hinshelwood. 1900. Letter-Word and Mind Blindness. Lewis, London.

46. Holzinger K.J. 1929. The Relative Effect of Nature and Nurture Influences on Twin Differences. J. Educ. Psych. Vol 20, 1929, 241 - 248.

47. Jastak J. The Ambigraph Laterality Test. J. App. Psych. 1939 - 23, 473 - 487.

48. Johnson W. and Duke D. The Dextrality Quotient of Fifty 6 year olds with re to Hand Usage. J. Educ. Psych. 1936 - 27.

49. Jones H.E. Dextrality as a Function of Age. J. Exper. Psych. 1931 - 14, 125 - 144.

50. Jones M.C. The Development of Early Behaviour Patterns in Young Children. J. Genet. Psych. 1926 - 33, 537 - 585.

51. Kirk S.A. 1934. A Study of the Relation of Ocular and Manual Preference to Mirror Reading. J. Genet. Psych. 1934, 44.

52. Koch H. 1933. A Study of the Nature, Measurement and Determination of Hand Preference. Genet. Psych. Monog. 1933 - 13, 117 - 218.

53. Koffka K. Principles of Gestalt Psychology. Routledge and Kegan Paul, London.

53a. Lashley K.S. 1929. Brain Mechanisms and Intelligence.

54. Lauterbach. 1924. Studies of Twin Resemblance. Genetics 1925 - 10, 525 - 568.

55. Lewis E.O. 1925 - 27. Report of the Mental Deficiency Committee. Part IV. Report on an Investigation into the incidence of Mental Deficiency in Six Areas. London. H.M. Stationery Office. 1929.

56. Lindsley D.B. Bilateral Differences in Brain Potentials from the 2 Cerebral Hemispheres in Relation to Laterality and Stuttering. J. Genet. Psych. 1938 - 19.

57. Lippman A.S. Certain Behaviour Responses in Early Infancy. J. Genet. Psych. 1927 - 34, 424 - 440.

58. Lund F.H. The Manoptometer. A New Device for Measuring Eye Dominance. Am. J. Psych. 1932 - 44, 181 - 183.

59. McIntosh D.M. 1944. The Effect of Practice in Intelligence Tests. J. Educ. Psych. Vol. XIV 1944.

60. MacMeekan A.M. 1937. The Intelligence of a Representative Group of Scottish Children. Pub. by S.C.R.E.

61. MacMeekan M. Ocular Dominance in Relation to Developmental Aphasia. Publication of Ross Foundation Univ. London Press. 1939.

62. MacMeekan M. Developmental Aphasia in Educationally Retarded Children. Publication of Ross Foundation Univ. London Press. 1942.

63. Mehrotra S.N. and Maxwell J. The Intelligence of Twins. A Comparative Study of Eleven year old Twins. Population Studies Vol. III, No. 3, 1949.

64. Merriman C. 1924. The Intellectual Resemblance of Twins. Psychol. Monog. Vol. 33 - 5. Princeton N.J. Psychol. Review Co.

65. Miles W.R. Ocular Dominance demonstrated by Unconscious Sighting. J. Exper. Psych. 1929 - 12, 113 - 126.

66. Mintz A. Reading Reversals and Lateral Preferences in a group of Intellectually Subnormal Boys. J. Educ. Psych. 1946 - 37, 487 - 501.

67. Mintz A. Lateral Preferences of a Group of Mentally Subnormal Boys. J. Genet. Psych. 1947 - 71, 75 - 84.

68. Morgan C.T. and Stellar E. 1950. Physiological Psychplogy. McGraw-Hill Book Co. New York : London.

69. Newman H.H. Studies of Human Twins II. Asymmetry, reversal or mirror-imaging in identical twins. Biol. Bull. 1928 - 55, 298 - 315.

70. Newman H.H. Twins and Super. Twins. London : Hutchison's Technical and Scientific Pubs. 1942.

71. Newman H.H., Freeman F.H., Holzinger K.J. Twins, a Study of Heredity and Environment. Chicago: Univ. Press. 1937.

72. Oates D.W. 1929. Lefthandedness in Relation to Speech Defects Intelligence and Achievement. (with 10 other works). Unpub. Thesis. Cardiff Univ.

73. Ojemann R.H. Studies in Handedness. J. Educ. Psychol. 1930 - 21, 597 - 611; 695 - 702.

74. Orton S.T. Word Blindness in School Children 1925. Arch. Neurol. and Psychiat. 1925 - 14, 581 - 615.

75. Orton S.T. Reading, Writing and Speech Problems in Children. London: Chapman and Hall Ltd. 1937.

76. Orton S.T. Visual Functions in Strephosymbolia. Arch. Opthalm. - 30, 1943 - 707 - 717.

77. Parson B.S. Lefthandedness: A New Interpretation. New York. MacMillan 1924.

78. Peel E.A. 1951. A Note on Practice Effects in Intelligence Tests. J. Educ. Psych. June 1951.

79. Quinan C. 1930. The Principal Sinistral Types. An Experimental Study particularly as regards their Relation to the so-called Constitutional Psychopathic States. Arch. Neur. and Psychiat. 1930 - 24, 35 - 47.

80. Quinan C. The Handedness and Eyedness of speeders and reckless drivers. Arch. Neur. and Psychiat. 1931 - 25, 829 - 837.

81. Raney E.T. Brain Potentials and Lateral Dominance in Identical Twins. 1938. Brown Univ. and Emma Pendleton Bradley Home.

82. Raney E.T. Reversed Lateral Dominance in Identical Twins. J. Exper. Psych. 1938 - 23, 304 - 312.

83. Jasper H.H. and Raney E.T. The Physiology of Lateral Cerebral Dominance. Psychol. Bull. 1937 - 34, 151 - 165.

84. Rife D.C. Genetic Studies of Monozygotic Twins. III Mirror Imaging. J. Hered. 1933 - 24, 443 - 446.

85. Rife D.C. 1943. Handedness and Dermatoglyphics in Twins. Hum. Biol. 1943 - 15.

86. Rife D.C. and Cummins H. Dermatoglyphics and Mirror Imaging. Hum. Biol. 1943.

87. Schaefer N. 1911. Die Linkshänder in der Berliner Gemeindeschulen Berliner. Klin. Wochensch. 1911 - 48, No. 7.

88. Schonell F.H. The Relation of Reading Disability to Handedness and certain Ocular Factors. Brit. J. Educ. Psych. 1940 - 10,3: 1941 - 11, 1.

89. Schonell F. 1942. Backwardness in the Basic Subjects. Oliver and Boyd.

90. Schonell F.J. 1949. Development of Educ. Research Brit. J. Educ. Psych. Vol. XIX Part II, 1949.

91. Simon C. Proactive Inhibition as an effect of Handedness in Mirror Drawing. 1948. J. Exper. Psych. Vol. 38.

92. Sinclair A.H.H. Developmental Aphasia. Brit. J. Ophthal. 1948. Vol. XXXII. No. 9.

93. Sleight. 1932. The Diagnosis and Treatment of the Backward Child. (Ph.D. Thesis 1932 - Univ. London Library).

94. Smith K.U. The Role of the Commissural Systems of the Cerebral Cortex in the Determination of Handedness, Eyedness and Footedness in Man. J. Gen. Psych. 1945 - 32, 39 - 79.

95. Smith L.G. 1917. A Brief Survey of Right and Left Handedness. J. Genet. Psych. 1927 - 24.

96. Snyder A.M. and M.A. 1928. Eye Preference Tendencies. J. Educ. Psych. 1928 - 19, 431 - 433.

97. Terman L.M. and Merrill M.A. 1937. Measuring Intelligence. Harrap & Co. 1937.

98. The Intelligence of Scott. Children. Univ. London Press. Pub. S.C.R.E. Nove. 1933.

99. The Trend of Scottish Intelligence. 1949. S.C.R.E. Univ. London Press.

100. Travis L.E. Speech Pathology. New York. D. Appleton-Century Co. 1931.

101. Turner E. Studies in Eye, Hand and Foot Preferences of emotionally unstable adolescents compared with stable adolescents. J. Juv. Research. April 1939. XXII No. 2.

102. Updegraff R. Preferential Handedness in Young Children. J. Exper. Educ. 1932 - 1, 134 - 139.

103. Van Riper. A New Test of Laterality. J. Exper. Psych. 1934 - Vol. 17, 305 - 313.

104. Van Riper. The Quantitative Measure of Laterality. J. Exper. Psychol. 1935 - Vol. 18, 372 - 382.

105. Vernon P.E. 1938. Intelligence Test Sophistication. J. Educ. Psych. Vol. VIII 1938.

106. Von Verschuer. 1927. Der Vererbungsbiologische Zwillingsvorschung. Ergeb. Innern Med. U. Kinderholt. 1927 - 31.

107. Voelckel E. Untersuchungen über die Rechtshandigkeit beim Saugling. Z. Rinderheil. 1913 - 8, 351 - 358.

108. Wallin J.E.W. Census of Speech Defectives among 89,057 Public School Pupils: A Prelim. Report. Sch. Soc. 1916 - 3.

109. Watson J.B. Psychology from the Standpoint of a Behaviourist. Philadelphia: Lippincott. 1919.

110. Wile I.S. 1934. Handedness: Right and Left. Boston. Lothrop, Lee and Shepard. 1934.

111. Wile I.S. and Davis R. A Study of Failures on the Stanford Binet in Relation to Behaviour and School Problems. J. Educ. Psych. 1941 - 32.

112. Wilson P.T. and Jones H.E. Lefthandedness in Twins. Genetics 1932 - 17, 560 - 571.

113. Wingfield A.H. and Sandiford P. Twins and Orphans. J. Educ. Psych. Vol. 19 1928, 410 - 423.

114. Witty P.A. and Kopel D. Studies of Eye Muscle Imbalance and Poor Fusion in Reading Disability. An Evaluation. J. Educ. Psych. 1936 - 2, 11.

115. Witty P.A. and Kopel D. Sinistral and Mixed Manual Ocular Behaviour in Reading Disability. J. Educ. Psych. 1936 - 27, 119 - 134.

116. Wolfe L.S. 1941. Differential Factors in Specific Reading Disability, Laterality of Function. J. Genet. Psych. 1941 - 58, 45 - 56.

117. Woody C. and Phillips A.J. 1934. The Effects of Handedness on Reversals in Reading. J. Educ. Res. 1934 - 27.

## Zusammenfassung und Schluss.

Eine Untersuchung der Handwahlen und Augenwahlen von Kindern wurde unternommen, die wegen klarer beispielhafter Erlernungseinmischungen das Lesen und das Buchstabieren mit Schwierigkeit studierten. Diese Schwierigkeiten mit Kindern, die Buchstaben und Wörter umkehrten, sind typisch für die sogenannte entfaltende Aphasie.

Eine Gruppe von mehr als tausend Kindern wurde von normalen Schulkindern, Zwillingen und einigen zurückgebliebenen, geistig wenig entwickelten Kindern zur Einzeluntersuchung gewählt.

Das Problem war das Ausmass des Einflusses im fundamentalen Schreiben, Buchstabieren und Lesen der Kinder, der Faktoren der Seitenkennzeichen welche das normale Lernen beeinflussen könnten, und die Art und Weise des Einflusses im allgemeinen zu studieren.

Um für eine Altersgruppe bis zu 12 Jahren eine gleichmässige Grundlage voraussetzen zu können, wurden Sprachkentnisse nur im Lesen und Buchstabieren geprüft.

Der A.Q. wurde als Hauptmass benutzt um den Einfluss der Faktoren, anderer als der der angeboren Intelligenz oder Dummheit, zu entdecken, die die Erziehung zurücksetzen. In der Zusammensetzung des A.Q. unter 100 wurde festgestellt, dass verschiedenartige

Einmischung beim Lernen von einem fast unwichtigen - bis zu einem ernsthaften Grad vorhanden war.

Das Ganze umfasste in erster Linie einen vollkommenen Überblick über das Zwischenspeil der Intelligenz - und Erlernungsfaktoren um festzustellen, wie weit die geistige Minderwertigkeit mit den Seitenkennzeichen in Verbindung gebracht werden konnte. Der relative Einfluss der Seitenkennzeichen und anderer bestehender Faktoren, welche Zurückgebliebenheit hervorrufen könnten, ist auch mit in Betracht gezogen worden.

Die allgemeinen Kennzeichen der ganzen Gruppe wurden zuerst untersucht. Es wurde festgestellt, dass das Intelligenzniveau dem Durchschnitt entsprach, ohne bedeutenden Unterschied zwischen Jungen und Mädel. Bei den Anwendungsproben wurde jedoch festgestellt, dass die Jungen schlechter waren wie die Mädel. Die ganze Gruppe nutzte ihre Intelligenz nur zu 87% aus. Es wurde deshalb klar, dass Zurückgebliebenheit in der Gruppe vorhanden war. Nur 7% der Kinder zeigten kein Sprachenproblem in dieser Arbeit wie sie durch Schulprüfungen ihrer Fähigkeit entsprechend gemessen wurden. Ein bedeutend grösserer Teil der Jungen wurde gefunden, die den Eindruck der Spracheinmischung zeigten, ganz abgesehen von ihren Fähigkeiten, während Mädel mit höherer Intelligenz schlechtere Ergebnisse schulmässig zeigten als solche mit weniger Intellekt.

Gründe für diese Unterschiede wurden im Studium der

Seitenkennzeichen in den verschieden Gruppen von 770 Kindern gesucht. Das Ausmass des Einflusses aphasischer Faktoren um Einmischung beim Lernen hervorzurufen, wurde im Zusammenhang mit der Intelligenz und des Könnens untersucht. Es wurde bestätigt, dass die Seitenkennzeichen in allen Variationen der Hand, ob rechts, links oder gemischt, keine bedeutungsvolle Beziehung zur Intelligenz des Einzelnen hatten. Dies war auch bei den verschieden Kindergruppen nicht unterschiedlich.

Die Kombination zwischen Hand und Auge war mehr Zufall in der Gruppe der normalen Kinder und unter den Zwillingen als unter den dummern Kindern.

Obwohl keine bedeutenden Unterschiede in den Seitenkennzeichen der ganzen Gruppe vorhanden waren die auf das Geschlecht zurückzuführen wären, zeigten mehr Jungen als Mädel eine gemischte Kombination zwischen Hand und Auge.

Eine Analyse der Hand und Augen Kategorien in Bezug auf die Schulprüfungen zeigte keine Bedeutung. Mädel, welche zufällige Kombinationen zwischen Hand und Augen hatten, schienen ein höheres Niveau zu haben im Vergleich mit Solchen gemischter Kombination, obwohl dies nicht bei den Jungen charakteristisch war.

Da die verschiedenen Kombinationen von Hand und Auge nicht die Hauptfaktoren für die Einmischung in Intelligenz und Leistung zu sein schienen, wurden weitere Untersuchungen

angestellt, um festzustellen ob irgendeine Verbindung zwischen den Seitenkennzeichen und dem Temperament bestände. Ein indirekter Einfluss könnte dann durch die Temperamentverbindung vorgeschlagen werden.

In der Untersuchung der Seitenkennzeichen und des Temperamentes zeigten alle Gruppen eine Verbindung der Linksrichtung und der gemischten Richtung mit der Unbeständigkeit. Kinder, die eine zufällige Wahl von Hand und Auge zeigten, hatten beständigere Charaktere als Solche mit gemischten Tendenzen. Die Gruppe der Jungen zeigte mehr Widerstandscharakteristiken und negative Temperamentneigungen als die Mädchengruppe. Ein bedeutender Geschlechtsunterschied wurde in der Zwillings - und Zurückgebliebenen Gruppe festgestellt.

Ein Faktor in der Erklärung der schlechteren Schulergebnisse der Jungen im Vergleich mit den Mädeln wurde also durch die Verbindung der Seitenkennzeichen und des Temperamentes klargestellt. Die Jungen zeigten mehr linkische - und gemischte Tendenzen als die Mädel. Mit der damit verbundenen Unbeständigkeit und den Widerstandscharakteren besteht also grössere Einmischung beim Lernen.

Die Gründe und Zustände, die die Seitenkennzeichen bestimmen, wurden von vier Seiten untersucht und eine Erklärung für die Häufigkeit der sich wiederholenden Tendenzen gesucht.

Theoretische Überlegungen der Seitenkennzeichen

in Bezug auf Ausbildung, Reife, neuralgische Faktoren und Vererbung zeigen wie jeder Faktor die Hand-Augen Kombination beeinflussen kann. Angeborene und äusserliche Umgebung werden künstliche Unterschiede, denn Kind wie Erwachsener werden in den Seitenkennzeichen durch Beide regiert, während die Wirkungskraft des Einzelnen zum grossen Teil durch die richtige Mischung und Integrierung der beitragenden Faktoren bestimmt wird.

Der Einfluss der Ausbildung, der Sitte und Gewohnheit in einer einseitigen Wahl dürfte nicht zu widerlegen sein. Die Häufigkeit der Fälle des Handwechsels solcher, die angeborene Linkshänder waren und durch Ausbildung die rechte Hand gebrauchten, schlägt vor, dass der Prozentsatz der angeborenen Linkshänder viel grösser ist als Schätzungen andeuten, weil die Ausbildung die natürliche Tendenz überdeckt. Während Übereinstimmung mit sozialen Sitten ein bedeutender Faktor in der Handauswahl erscheint, scheint das Verlangen der Umgebung temperamentale Schwierigkeiten für den Linkshänder zu schaffen, wodurch der Widerstand erhöht wird und die Ausbildung nur teilweise erfolgreich ist. Ein Kind mit einer Rechtshand - Linksaugen Mischung kann das Ergebniss des Wechselns der linken Hand in einem volkommen linkischen Kind sein. Ein starker biologischer Faktor der Seitenkennzeichen würde so vorhanden sein. Einmischung in die natürlichen linkischen Tendenzen in obengenannten Fall sollte mit Vorsicht vorgenommen werden.

Eine Betrachtung der Reife und des Wachstums unter den dummen Kindern zeigt beim grösseren Prozentsatz der Mischfälle, dass schlechtes biologisches Material die Reife der einseitigen Entscheidung nicht zu besitzen scheint. Oder es kann sein, dass die Hand-Augenwahl eine angelernte Kunst ist, sodass unbeständige und schlecht integrierte Nervensysteme in diesen Kindern ein Grund für die grössere Unfähigkeit zur Augen und Hand Koordinierung sind.

Die Betrachtung der Temperamentfaktoren vom neurologischen Standpunkt unterstützt eine Theorie der zunehmenden Gehirnerregung oder eine Unterbrechung des Rhythmuses der Gehirnneurone. Diese Zustände, zusammen mit einer Verlangsamung der spontanen Arbeit der Gehirnzellen, scheinen mehr bei den Mischfällen oder bei denen, wo die natürliche Handauswahl unterbunden wurde, charakteristisch zu sein.

Zuletzt schlagen die Beobachtungen der Seitenkennzeichen vor, dass ein Vererbungsfaktor vorhanden sei. Die Rechtstendenz scheint der dominierende mendelsche Faktor zu sein gegenüber der Linkstendenz. Jedoch das grosse Ausmass der Linkstendenz in der Zwillingsgruppe und der hohe Prozentsatz der Mischfälle in der Gruppe der Dummen lassen darauf schliessen, dass ein niederdrückender Wachstumsfaktor in der frühen Umgebung vorhanden sei, welcher zu biologischen Minderwertigkeiten führt.

Während Vieles noch hypothetisch ist, scheint es

doch bewiesen, dass die Hand und Augen-Kombinationen keinen Einfluss auf die Intelligenz haben. Im Gegenteil, wie das Lernen mit der Reife fortschreitet zu einem fortgeschrittenen reifen Niveau, so wird die verfeinerte gleichmässige Bewegung der Hand-Augentätigkeit mehr die integrierte Arbeit des ganzen Gehirns, weshalb woher die Erziehung eine wichtige Rolle in der Auswahl und Lenkung spielt.

Ebenso scheinen Kinder durch verschiedene Hand und Augen Kombinationen in ihren Leistungen nicht zurückgesetzt zu sein, wie dies durch einfache Prüfungen festgestellt wurde. Doch scheint genug Beweis vorhanden zu sein, dass die Schulergebnisse indirekt durch die Seitenkennzeichen durch negative temperamentale Charakteristiken beeinflusst werden, welche bedeutungsvoller Weise bei Kindern mit Misch - und Linkstendenzen auftreten. Diese herabsetzenden Einflüsse dürften am stärksten in den ersten Schuljahren vorhanden sein, obwohl die Auswirkungen noch während der späteren Kinderjahre zu fühlen sind. Die Kindergruppen, welche untersucht wurden, waren am Ende ihrer Grundschuljahre, obwohl die Neigungen und Charakteristiken entschieden und von Bedeutung waren.

Linkshändigkeit kann organisch bestimmt sein und Versuche, die konstitutionelle Vererbung zu ändern, treffen daher auf temperamentale Widerstände. Doch von den Ergebnissen der vorangegangenen Untersuchung konnte man auch sagen, dass vererbte Unstabilität des Temperaments

der bedeutende Faktor ist, der mit der Linkstendenz und dem zweitgradigen Effekten der Mischtendenz zusammengeht. Das Fehlen körperlicher und geistiger Integration könnte daher ein Gesichtszug der allgemeinen Gleichgewichtsstörung in einer Person von unstabiler Persönlichkeit sein.

Da bei dem jetzigen Stand der Wissenschaft ein Endergebniss nicht möglich ist, ist weitere Forschung auf dem Gebiet des Temperaments und der Persönlichkeit nötig ehe man endgültig feststellen kann in wie weit die Seitenkennzeichen Grund oder Auswirkung der Ordnung oder Unordnung im Einzelnen sind.

## Sumario y Conclusión.

Se hizo un estudio de los característicos de lateralidad (coordinación de mano y ojo) de los niños que mostraron dificultad en asimilación, de la habilidad basica en leer y ortografía á causa de ejemplaros claros de dificultad en aprender; consisten éstos en una tendencia de mezclar letras y palabras que son típicas de una llamada afasia en desarrollo.

Se escogió un grupo experimental de más de mil niños para una investigación individual y el grupo incluyó niños de una población escuela normal, uno grupo de gemelos y un grupo de niños aprasados y de baja inteligencia.

El problema era de estudiar la magnitud de la influencia, si existiese, en la facilidad de habla de estos niños, de las causas por la lateralidad, que pudieren causa una dificultad en aprender normal y de estudiar más de la incidencia y la natura de la lateralidad en general.

Para tener un medio que sería bastante uniform para un grupo de edad 7 - 12 se medio capacidad de habla en leer y escribír solamente. El resultado de habilidad (A.Q.) se uso como un medio principal de descubrir la influencia de causas distintas del nivel bajo de inteligencia en crear atraso d'educación. En los

resultados de A.Q. bajo ciento se descubrió una cantidad de incapacidad para aprender variando de muy poca á muy seriosa.

Todo comprendió primeramente una consideración comprensiva del juego de característicos de inteligencia y de conseguimiento en esta situación para establecer la incidencia de atraso en el grupo estando presente el grado de dificultad de lateralidad. Se ha considerado la influencia de lateralidad y de otras causas produciendo el atraso.

Se consideraron primeramente los característicos más generales del grupo total. Se descubrió que el nivel de inteligencia del grupo casi igualabra éste del niño medio, no existiendo diferencia importante entre los niños y las niñas. En las pruebras de habilidad sin embargo se descubrió que los niños estubieron de un nivel mucho inferior a éste de las niñas mientras que el grupo total trabajaba a solo 87 porciento de su capacidad.

Se concluyó por lo tanto que existía un atraso en el grupo. Solo unos siete porciento de los niños manifestaron ninguna dificultad visto que el trabajo medido por pruebas educacionales se igualó con la habilidad. Se halló una proporcion más grande de niños que aparecío mostrar el impreso de dificultad de habla fuera de su capacidad mientras que las niñas de inteligencia más alta mostraron un nivel más bajo

d'educación que las niñas de un nivel más bajo de inteligencia.

Se buscaron razones por estas diferencias en un estudio de los característicos de lateralidad en los grupos diferentes de 770 de estos niños. El grado de la operación de los factores de afasia causando dificultades de aprender se estudió en relación á la inteligencia y habilidad en cumplimiento.

Pareció evidente que la lateralidad en todas sus variaciones de mano derecha, izquierda y mano y ojo mezclados, no tenía relación significante á la inteligencia del individuo. Pareció verdadero de los tipos diferentes de niños de poca inteligencia, gemelos y normales.

Se descubrió más coordinación de mano y ojo en los grupos normales y gemelos, que en el grupo de niños de poca inteligencia.

Aunque ninguna diferencia significante de sexo se halló en la lateralidad del grupo total, más niños que niñas mostraron un predominio de mano y ojo mezclados.

Un análisis de las categorías de mano y ono con resultados en las pruebas educacionales estableció ninguna significancia de lateralidad con cumplimiento. Las niñas que mostraron una coordinación de mano y ojo parecieron llegar a un nivel más alto de cumplimiento que éstas de mano y ojo mezclados aunque no era característico de los niños.

Como las combinaciones diferentes de mano y ojo

no aparecieron ser grandes factores causativos en inteligencia o cumplimiento se hizo una investigación ulterior para establecer si existiese una relación significante entre los factores de lateralidad y de temperamento. Una influencia indirecta pudiese sugerirse por la conexión temperamental.

Las indicaciones en el análisis de la lateralidad y del temperamento mostraron en todos los grupos una asociación de tendencia siniestra y ojo y mano mezclados con instabilidad. Los niños que revelaron coordinación de mano y ojo mostraron característicos más constantes que éstos de mano y ojo mezclados. Se descubrió que los niños considerados como un grupo mostraron característicos resistencia y tendencias de temperamento negativas más que las niñas y una diferencia de sexo significante se descubrió en los grupos gemelos y astrasados.

Un factor en la explicación del cumplimiento más bajo d'educación de los niños comparado con éste de las niñas se estableció por lo tanto en esta conexión de lateralidad y temperamento. Los niños revelaron una incidencia más grande de tendencia siniestra que las niñas y más evidencia de mezcla de mano y ojo. Á causa de característicos más grandes de conexión entre instabilidad y resistencia se podía que mostrasen más dificultad en aprender.

Pues se consideraron las condiciones determinando la

lateralidad a la luz de cuatro métodos diferentes y importantes de tratar el problema y se buscó una explicación para la multiplicidad de tendencias en los datos.

La consideración teorica de lateralidad á la luz d'educación, maduración, factores neurológicos y herediarios revela como cada aspecto puede influir sobre coordinación de mano y ojo en el individuel. Las circumstancias internas y externas se hacen distinciones artificiales, que el niño ó el adulto es governado por los dos en lateralidad mientras que la eficiencia del individuo es determinada en gran parte por un equilibrio justo y integración de los aspectos contribuyentes.

Parece ser imposible negar la importancia de la educación, de los hábitos y usos en determinando la 'unilateralidad' (preferencia de una mano sbbre la otra). La existencia de niños con preferencia de la mano izquierda educados á usar la mano derecha indicara que el por ciento de ninos nacidos con preferencia de la mano izquierda sea mucho más alto que las indicaciones nos hacen estimar, pero la educación oculta tendencia natural.

Sin embargo mientras la conformidad al uso social parecería ser un factor importante en la selección de mano las circumstancias externas pudieron crear dificultades de temperamento para él con preferencia por la mano

izquierda siendo acrecentadas resistencias y la educación puede lograr solo en parte. Un niño con tendencia de mano derecha y ojo izquierdo puede resultar del esfuerzo de cambiar de mano en un niño puramente de mano siniestra. Un factor determinante fuertemente biológico de lateralidad parecería ser presente. En tal tipo se debe considerar con mucho cuidado la enterferencia con la tendencia natural de ser siniestro de mano.

Una consideración de los factores de maduración y de crecimiento muestra que entre los niños de poca inteligencia el más gran por c iento de niños de mano y ojo mezclados hallados puede indicar que los niños de pobre constitución biológica tiene tendencia a carecer de los factores determinantes de maduración en fuerza de mano y ojo ó puede indicar que esta fuerza es un modo de conducta adquirido de modo que sistemas nerviosos de pùbre estructura en estos niños tienen obstáculos más grandes en estabiliciendo sistemas de coordinacion de mano y ojo. Una consideración de factores de temperamento de un punto de vista neurológico apoyara una teoría de una excitación cerebral augmentada ó una disrupción del sincronismo de los neurones del sistema nervioso. Estas condiciones con reducción del ritmo espontáneo en las células puedan ser más características de los casos de mezcla de mano y ojo ó en los casos donde se ocurrió una intervención con la selección natural de la mano.

Finalmente las tendencias de lateralidad observadas en los grupos diferentes pudieron sugerir que existe un factor genético de manera que tener preferencia por la mano diestra puede ser considerada como un característico dominante de 'Mendel', mientras que la preferencia por la mano siniestra pudiera ser el característico de recesso de 'Mendel'.

Sin embargo en el grupo de mellizos la alta incidencia de preferencia por la mano siniestra con un alto por ciento de preferencia por mano y ojo mezclados y indeterminada, apoyase la idea que existe algún agente impidiando el crecimiento en el feto que cuasa inferioridades biológicas.

Mientras que esto mucho especulativo en ésta parecería probado que combinaciones de mano y ojo no influyen sobre la inteligencia. Al contrario como el aprender procede con la maduración sugerimos que á un nivel de desarrollo avanzado y maduro la especialisacion de l'actividad de la mano y del ojo en movimientos coordinados se hace una función de la acción de integración del crebral entero, y que el aprender hace un gran papel en escogiendo y guiándo la reaccion. Los niños no parecen hallar obstáculos en las combinaciones diferentes de mano y ojo en cumplimiento educacional medidos en pruebas sencillias de habilidades basicas. Sin embargo existe razón por creer que los resultados educacionales pueden ser afectados indirectamente por lateralidad por característicos temperamentales negativos que parecen asociase con niños

mostrando tendencia siniestra ó de mezcla de mano y ojo. Estas influencias malas pueden operar más fuertemente ó iniciarse en los primeros años d'educación de escuela: sin embargo sus efectos parecieran perdurar por los años de niñez más avanzada. Los presentes grupos de ninos fueran estudiados al fin del período de la escuela primaria. Sin embargo las tendencias y característicos medidos fueron definidos y de significancia.

Tenir preferencia por la mano izquierda puede ser determinado organicamente y esfuerzos para cambiar la herencia constitucional puede por esta razón encontrar resistancias temperamentales, sin embargo a juzgar por los resultados de este estudio puede ser que una instabilidad de temperamento heredada sea el factor importante asociado con expresión sinistral y efectos secundarios de preferencias por mano y ojo mezclados ó sin preferencia fuerte de coordinación de mano y ojo. Falta de coordinación muscular y nerviosa puede ser por lo tanto un factor de un desequilibrio general ó desarreglo en un individuo de personalidad inconstante. Puesto que teniendo las ciencias que tenemos la finalidad no es posible, serían necesarias investigaciones ulteriores en la esfera del temperamento y de la personalidad antes de establecer definitivamente la influencia que tiene la lateralidad sobre el equilibrio o desequilibrio del individuo.

# APPENDIX A.

## Appendix A - Form 1 a.

## Scoring Sheet for Trial Performance Tests.

### Trial Tests.

**Hoopla Test.**

Preferred Hand =

(a) Trials. 1 ..... 2 ..... 3 .....

Non-preferred Hand =

Trials. 1 ..... 2 ..... 3 .....

**Bean Bag.**

Preferred Hand =

(b) Trials. 1..... 2 ..... 3 .....

Non-preferred Hand =

Trials. 1 ..... 2 ..... 3 .....

(c) **Peg Board.**

Preferred Hand =

No. in ½ minute .....

Composite Av. Score.
a,b,c.

=

Non-preferred Hand =

No. in ½ minute .....

Composite Av. Score
a,b,c.

=

---

Name .....

School .....

Date of Birth .....

Date of Test .....

## Appendix A - Form 2 a.

## Scoring Sheet for Final Performance Tests.

### Eyedness Tests.

1. Telescope Eye Preference -

   Trials. 1 ..... 2 ..... 3 .....

2. Ruler Tests -

   Trials. 1 ..... 2 ..... 3 .....

3. T-hole Eye Preference -

   Trials. 1 ..... 2 ..... 3 .....

### Hand Tests.

(a) Hoopla Test -

| Preferred Hand = | | Non-preferred Hand = | |
|---|---|---|---|
| Trials 1 ..... | 5 ..... | Trials 1 ..... | 5 ..... |
| 2 ..... | 6 ..... | 2 ..... | 6 ..... |
| 3 ..... | 7 ..... | 3 ..... | 7 ..... |
| 4 ..... | 8 ..... | 4 ..... | 8 ..... |
| Total Score ..... | | Total Score ..... | |

(b) Bean Bag -

| Preferred Hand = | | | Non-preferred Hand = | | |
|---|---|---|---|---|---|
| Trials 1 ..... | 5 ..... | 9.... | Trials 1 ..... | 5 ..... | 9..... |
| 2 ..... | 6 ..... | 10.... | 2 ..... | 6 ..... | 10.... |
| 3 ..... | 7 ..... | | 3 ..... | 7 ..... | |
| 4 ..... | 8 ..... | | 4 ..... | 8 ..... | |
| Total Score ..... | | | Total Score ..... | | |

(c) Peg Board -

| Preferred Hand = | Non-preferred Hand = |
|---|---|
| No. in 1 minute = | No. in 1 minute = |
| Composite Av. Score, a,b,c = | Composite Av. Score a,b,c = |

### Van Riper.

| Degrees | | Hand Mirroring |
|---|---|---|
| Kinaesthetic Pattern ..... | = | ..... |
| Script Pattern ..... | = | ..... |
| Visual Pattern ..... | = | ..... |
| Composite Av. Score | = | ..... |

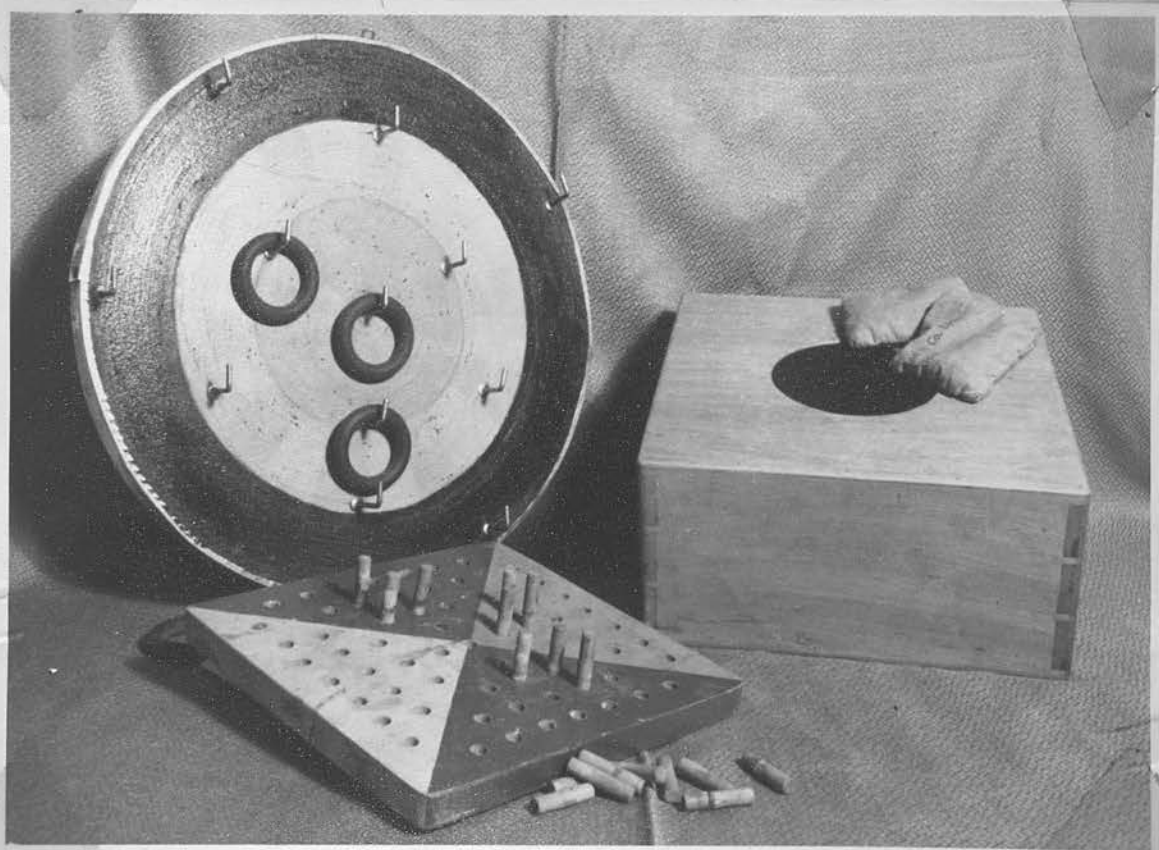
---

Name ..... Date of Birth .....

School ..... Date of Test .....

Appendix A.

Illustration 3 a.

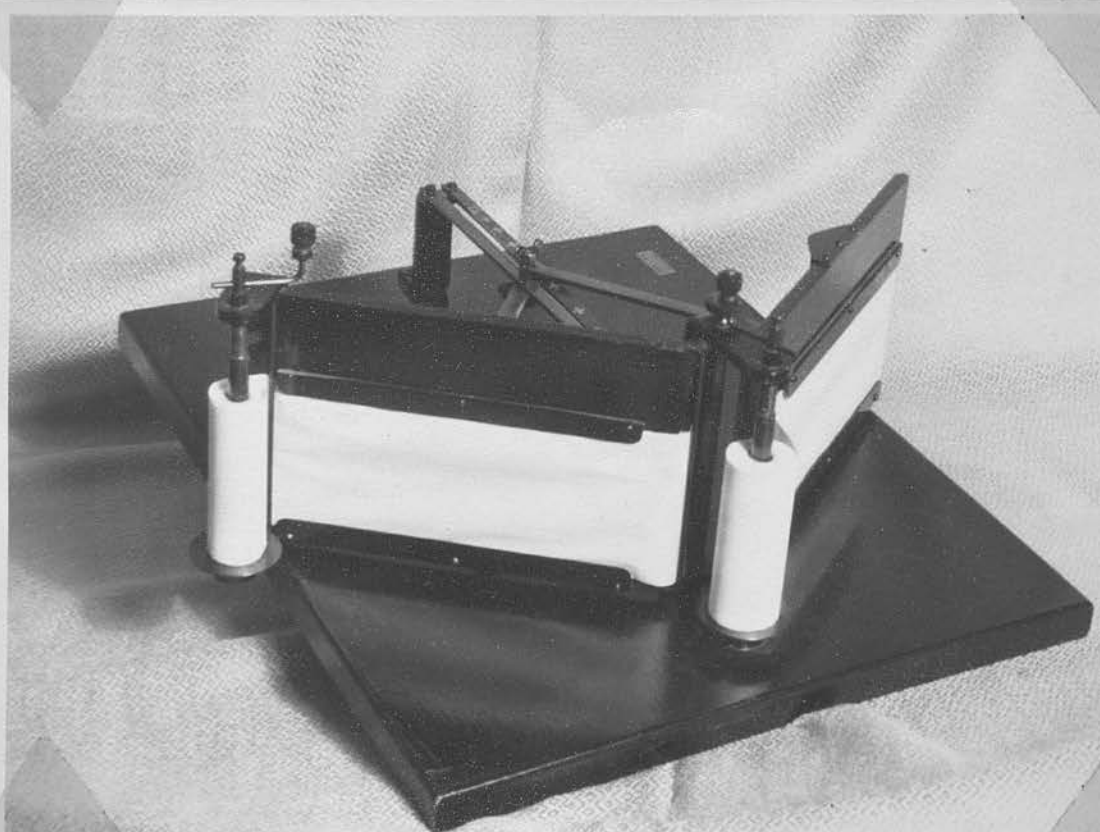


Photograph of:

Hoopla Board, Bean Bags and Box, Peg Board and Pegs.

Appendix A.

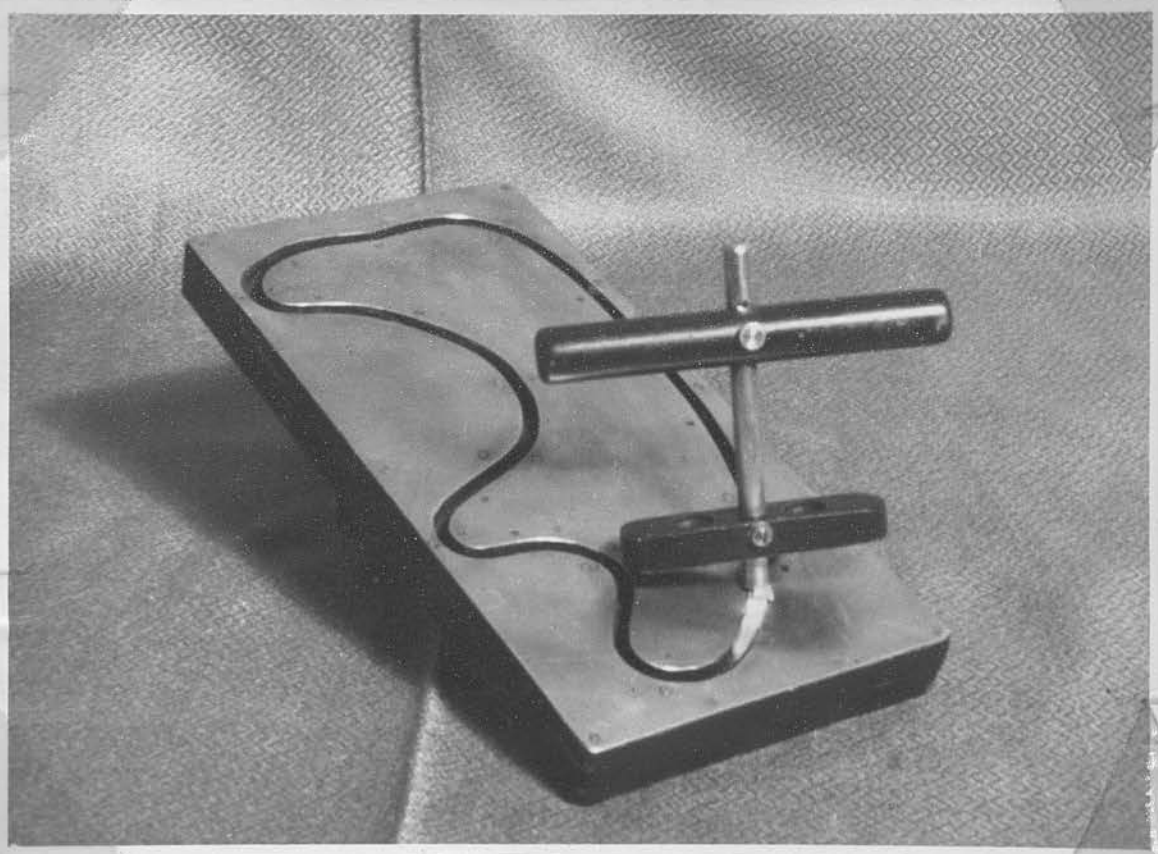
Illustration 4 a.



Van Riper Critical Angle Board.

Appendix A

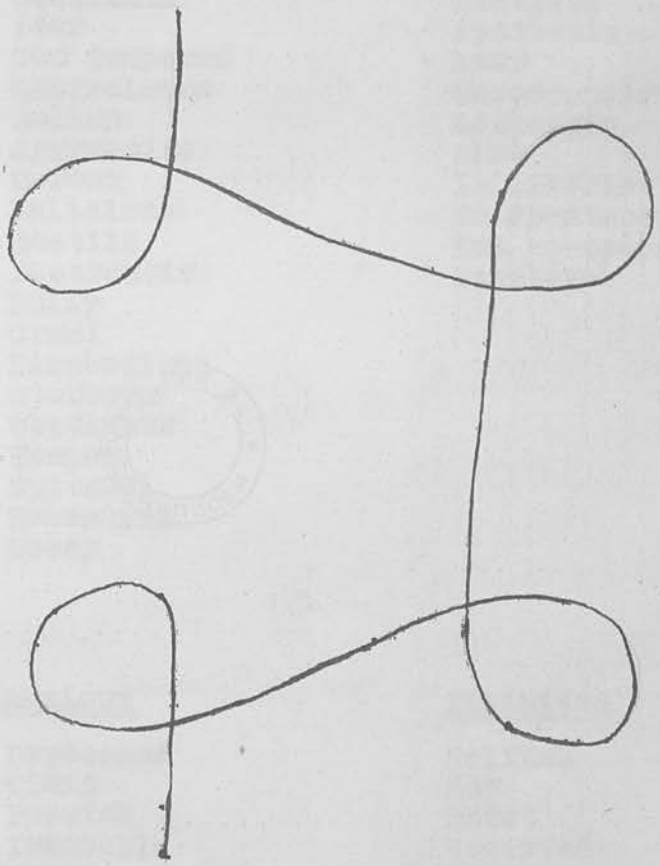
Illustration 5 a.



Kinaesthetic Pattern and Stylus.

Appendix A

Illustration 6 a.



Visual Pattern.

## Appendix A

### Illustration 7 a.

### Adjectives used under each heading.

| Stable | Resistant - Aggressive or Active | Resistant - Negative or Passive. |
|---|---|---|
| Industrious | Obstinate | Listless |
| Energetic | Dour | Apathetic |
| Independent | Bad tempered | Lazy |
| Inquisitive | Quarrelsome | Unresponsive |
| Placid | Sullen | Lethargic |
| Steady | Aggressive | Slow |
| Keen | Morose | Indifferent |
| Self-assertive | Malicious | No spontaneity |
| Attentive | Hostile | Non co-operative |
| Active | Destructive | Negative |
| Self-contained | Bully | |
| Confident | Cruel | |
| Happy-go-lucky | Disobedient | |
| Normal | Stubborn | |
| Tries Hard | Obstinate | |
| Friendly | Temper | |
| Co-operative | Spiteful | |
| Responsive | Resentful | |
| Sociable | Bossy | |
| Spontaneous | | |
| Cautious | | |
| Sensitive | | |

| Unstable | Anxious | Inhibited |
|---|---|---|
| Changeable | Depressed | Selfish |
| Impulsive | Timid | Shy |
| Careless | Peevish | Quiet |
| Distractible | Irritable | Reserved |
| Excitable | Weepy | Inhibited |
| Untidy | Nervous | Overdocile |
| Inattentive | Insecure | Overprotected |
| Erratic | Lacks confidence | Overdependent |
| Exhibitionist | Apprehensive | Overindulged |
| Restless | Anxious | Self-conscious |
| Mercurial | Fearful | Inoffensive |
| Teasing | Childish | Dependent |
| Lacks concentration | | Overtrusting |
| Lacks discrimination | | |
| Lacks perseverance | | |
| Talkative | | |

Adjectives contd.

| Delinquent | Neurotic and Unsociable |
|---|---|
| Tricky | Feels ostracised |
| Deceitful | Dreamy |
| Wandering | Persecution complex |
| Untruthful | Solitary |
| Delinquent | Feels inferior |
| Evasive | Disturbed |
| Truant | Enuretic |
| Pilfers | Unsociable. |

# APPENDIX B.

## Appendix B

## Table 1

## Scattergram of Test L with M

### Total Group.

| L Scale | 40-49 | 50-59 | 60-69 | 70-79 | 80-89 | 90-99 | 100-109 | 110-119 | 120-129 | 130-139 | 140-149 | 150-159 | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 170-179 | | | | | | | | | | | | 2 | 2 |
| 160-169 | | | | | | | | | 1 | 1 | 1 | | 3 |
| 150-159 | | | | | | | | | 1 | 1 | | | 2 |
| 140-149 | | | | | | | | | 4 | 2 | | | 6 |
| 130-139 | | | | | | | 1 | 2 | 9 | 5 | 1 | | 18 |
| 120-129 | | | | | | 1 | 2 | 14 | 14 | 7 | | | 38 |
| 110-119 | | | | | | 5 | 19 | 39 | 13 | 3 | 1 | | 80 |
| 100-109 | | | | | 1 | 32 | 61 | 35 | 5 | 1 | | | 135 |
| 90- 99 | | | | 3 | 35 | 95 | 50 | 6 | 2 | | | | 191 |
| 80- 89 | | | 3 | 66 | 129 | 72 | 7 | 2 | | | | | 279 |
| 70- 79 | | | 24 | 134 | 53 | 3 | | | | | | | 214 |
| 60- 69 | | 12 | 36 | 19 | 2 | | | | | | | | 69 |
| 50- 59 | 1 | 5 | 1 | | | | | | | | | | 7 |
| I.Q. | 40-49 | 50-59 | 60-69 | 70-79 | 80-89 | 90-99 | 100-109 | 110-119 | 120-129 | 130-139 | 140-149 | 150-159 | 1044 |

M Scale

## Appendix B.

## Table 2.

## Scattergram of 2nd I.Q. with 2nd A.Q.

## Total Group.

| I.Q. | 40-49 | 50-59 | 60-69 | 70-79 | 80-89 | 90-99 | 100-109 | 110-119 | 120-129 | 130-139 | 140-149 | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150-159 | | | | 1 | 1 | | | | | | | 2 |
| 140-149 | | | | 3 | | | | | | | | 3 |
| 130-139 | | | | 8 | 11 | 1 | | | | | | 20 |
| 120-129 | | | | 12 | 24 | 12 | 1 | | | | | 49 |
| 110-119 | | | 4 | 14 | 38 | 34 | 8 | | | | | 98 |
| 100-109 | | | 6 | 12 | 43 | 53 | 24 | 2 | | | | 140 |
| 90-99 | | 5 | 18 | 34 | 48 | 62 | 35 | 6 | | | | 208 |
| 80-89 | 1 | 7 | 25 | 36 | 52 | 57 | 29 | 9 | 2 | 1 | 1 | 220 |
| 70-79 | 1 | 8 | 26 | 45 | 52 | 57 | 24 | 6 | 3 | | | 222 |
| 60-69 | | 1 | 8 | 16 | 16 | 15 | 4 | 4 | | | | 64 |
| 50-59 | | | 4 | 1 | 3 | 3 | 4 | 2 | | | | 17 |
| | | | | | | | | 1 | | | | 1 |
| | | | | | | | | | | | | 1044 |

A.Q.

## Appendix B

### Table 3

### Percentages of Hand-Eye categories at 1st Testing.

### Total Group.

| Category | Boys | Percent | Girls | Percent | All | Percent |
|---|---|---|---|---|---|---|
| RH.RE | 325 | 54.62 | 272 | 60.58 | 597 | 57.18 |
| RH.LE | 212 | 35.63 | 132 | 29.39 | 344 | 32.95 |
| LH.LE | 26 | 4.35 | 19 | 4.23 | 45 | 4.31 |
| LH.RE | 32 | 5.38 | 26 | 5.77 | 58 | 5.55 |
| N | 595 | | 449 | | 1044 | |

### Table 4

### Percentages of Hand-Eye categories at 1st Testing.

### Retarded Group.

| Category | Boys | Percent | Girls | Percent | All | Percent |
|---|---|---|---|---|---|---|
| RH.RE | 177 | 53.63 | 113 | 59.47 | 290 | 55.76 |
| RH.LE | 121 | 36.66 | 60 | 31.57 | 181 | 34.80 |
| LH.LE | 14 | 4.23 | 9 | 4.73 | 23 | 4.42 |
| LH.RE | 18 | 5.45 | 8 | 4.21 | 26 | 5.00 |
| N | 330 | | 190 | | 520 | |

## Appendix B

### Table 5.

### Percentages of Hand-Eye categories at 1st Testing

### Normal Group.

| Category | Boys | Percent | Girls | Percent | All | Percent |
|---|---|---|---|---|---|---|
| RH.RE | 54 | 66.66 | 57 | 57.57 | 111 | 61.66 |
| RH.LE | 21 | 25.92 | 34 | 34.34 | 55 | 30.55 |
| LH.LE | 0 | 0 | 4 | 4.04 | 4 | 2.22 |
| LH.RE | 6 | 7.4 | 4 | 4.04 | 10 | 5.55 |
| N | 81 | | 99 | | 180 | |

### Table 6

### Percentages of Hand-Eye categories at 1st Testing

### Twin Group.

| Category | Boys | Percent | Girls | Percent | All | Percent |
|---|---|---|---|---|---|---|
| RH.RE | 91 | 54.81 | 105 | 58.98 | 196 | 56.97 |
| RH.LE | 57 | 34.33 | 51 | 28.65 | 108 | 31.39 |
| LH.LE | 8 | 4.81 | 10 | 5.61 | 18 | 5.23 |
| LH.RE | 10 | 6.02 | 12 | 6.74 | 22 | 6.39 |
| N | 166 | | 178 | | 344 | |

## Appendix B

### Table 7.

### Incidences in each Category of Hand and Eye.

### Total Laterality Group - 770 Children.

| Category of Hand and Eye | Boys | Percent | Girls | Percent | All | Percent |
|---|---|---|---|---|---|---|
| RH.RE | 168 | 39.13 | 161 | 47.21 | 329 | 42.72 |
| RH.LE | 130 | 30.30 | 81 | 23.75 | 211 | 27.40 |
| LH.LE | 38 | 8.85 | 34 | 9.97 | 72 | 9.35 |
| LH.RE | 77 | 17.94 | 53 | 15.54 | 130 | 16.88 |
| Ambi-R | 7 | 1.63 | 9 | 2.63 | 16 | 2.07 |
| Ambi-L | 9 | 2.09 | 3 | .87 | 12 | 1.55 |
| N | 429 | | 341 | | 770 | |

## Appendix B

### Table 8

### Retarded Laterality Subgroup.

Numbers and Percentages in each Hand-Eye Category.

| Category | Boys | Percent | Girls | Percent | All | Percent | |
|---|---|---|---|---|---|---|---|
| RH.RE | 69 | 36.31 | 48 | 43.63 | 117 | 39. | |
| RH.LE | 64 | 33.68 | 30 | 27.27 | 94 | 31.33 | 49.7 |
| LH.LE | 13 | 6.84 | 10 | 9.09 | 23 | 7.66 | |
| LH.RE | 33 | 17.36 | 16 | 14.54 | 49 | 16.33 | |
| Ambi-R | 5 | 2.63 | 3 | 2.72 | 8 | 2.66 | |
| Ambi-L | 6 | 3.15 | 3 | 2.72 | 9 | 3. | |
| N | 190 | | 110 | | 300 | | |

### Table 9

### Normal Laterality Subgroup.

Numbers and Percentages in each Hand-Eye Category

| Category | Boys | Percent | Girls | Percent | All | Percent | |
|---|---|---|---|---|---|---|---|
| RH.RE | 36 | 37.88 | 37 | 49.33 | 73 | 42.94 | |
| RH.LE | 29 | 30.52 | 16 | 21.33 | 45 | 26.47 | 44.1 |
| LH.LE | 11 | 11.57 | 5. | 6.66 | 16 | 9.41 | |
| LH.RE | 16 | 16.84 | 14 | 18.66 | 30 | 17.64 | |
| Ambi-R | 1 | 1.05 | 3 | 4. | 4 | 2.35 | |
| Ambi-L | 2 | 2.10 | 0 | 0 | 2 | 1.17 | |
| N | 95 | | 75 | | 170 | | |

## Appendix B

### Table 10.

### Twin Laterality Subgroup.

Numbers and Percentages in each Hand-Eye Category

| Category | Boys | Percent | Girls | Percent | All | Percent |
|---|---|---|---|---|---|---|
| RH.RE | 63 | 43.75 | 76 | 48.71 | 139 | 46.33 |
| RH.LE | 37 | 25.69 | 35 | 22.43 | 72 | 24. |
| LH.LE | 14 | 9.72 | 19 | 12.17 | 33 | 11. |
| LH.RE | 28 | 19.44 | 23 | 14.74 | 51 | 17. |
| Ambi-R | 1 | .69 | 3 | 1.91 | 4 | 1.33 |
| Ambi-L | 1 | .69 | 0 | 0 | 1 | .33 |
| N | 144 | | 156 | | 300 | |

## Table 11

### Numbers and Percentages in Total Laterality Group with Non-retarded withdrawn.

| Category | Boys | Percent | Girls | Percent | All | Percent |
|---|---|---|---|---|---|---|
| RH.RE | 157 | 41.31 | 128 | 47.40 | 285 | 43.84 |
| RH.LE | 110 | 28.94 | 65 | 24.07 | 175 | 26.92 |
| LH.LE | 32 | 8.42 | 24 | 8.88 | 56 | 8.61 |
| LH.RE | 69 | 18.15 | 44 | 16.29 | 113 | 17.38 |
| Ambi-R | 7 | 1.84 | 7 | 2.59 | 14 | 2.15 |
| Ambi-L | 5 | 1.31 | 2 | .74 | 7 | 1.07 |
| N | 380 | | 270 | | 650 | |

## Appendix B

### Table 12

### Retarded Subgroup less non-retarded.

| Category | Boys | Percent | Girls | Percent | All | Percent |
|---|---|---|---|---|---|---|
| RH.RE | 65 | 36.72 | 43 | 43.43 | 108 | 39.13 |
| RH.LE | 58 | 32.76 | 29 | 29.22 | 87 | 31.52 |
| LH.LE | 13 | 7.34 | 9 | 9.09 | 22 | 7.97 |
| LH.RE | 32 | 18.07 | 13 | 13.13 | 45 | 16.30 |
| Ambi-R | 5 | 2.82 | 3 | 2.03 | 8 | 2.86 |
| Ambi-L | 4 | 2.26 | 2 | 2.02 | 6 | 2.17 |
| N | 177 | | 99 | | 276 | |

### Table 13

### Normal Subgroup less Non-retarded.

| Category | Boys | Percent | Girls | Percent | All | Percent |
|---|---|---|---|---|---|---|
| RH.RE | 32 | 38.55 | 27 | 50.94 | 59 | 43.38 |
| RH.LE | 24 | 28.91 | 8 | 15.09 | 32 | 23.52 |
| LH.LE | 9 | 10.84 | 2 | 3.77 | 11 | 8.08 |
| LH.RE | 16 | 19.27 | 14 | 26.40 | 30 | 22.05 |
| Ambi-R | 1 | 1.20 | 2 | 3.77 | 3 | 2.20 |
| Ambi-L | 1 | 1.20 | 0 | 0 | 1 | .73 |
| N | 83 | | 53 | | 136 | |

Table 14

Twin Subgroup less Non-retarded.

| Category | Boys | Percent | Girls | Percent | All | Percent |
|---|---|---|---|---|---|---|
| RH.RE | 60 | 50. | 58 | 49.15 | 118 | 49.57 |
| RH.LE | 28 | 23.33 | 28 | 23.62 | 56 | 23.52 |
| LH.LE | 10 | 8.33 | 13 | 11.01 | 23 | 9.66 |
| LH.RE | 21 | 17.50 | 17 | 14.40 | 38 | 15.96 |
| Ambi-R | 1 | .83 | 2 | 1.79 | 3 | 1.26 |
| Ambi-L | 0 | 0 | 0 | 0 | 0 | 0 |
| N | 120 | | 118 | | 238 | |

Appendix B

Table 15

Non-Retarded Group N = 120

| Category | Boys | Percent | Girls | Percent | All | Percent |
|---|---|---|---|---|---|---|
| RH.RE | 11 | 22.44 | 33 | 46.47 | 44 | 36.66 |
| RH.LE | 20 | 40.80 | 16 | 22.53 | 36 | 30.00 |
| LH.LE | 6 | 12.24 | 10 | 14.08 | 16 | 13.33 |
| LH.RE | 8 | 16.32 | 9 | 12.67 | 17 | 14.16 |
| Ambi-R | 0 | 0 | 2 | 2.81 | 2 | 1.66 |
| Ambi-L | 4 | 8.16 | 1 | 1.40 | 5 | 4.16 |
| N | 49 | | 71 | | 120 | |

## Appendix B

## Table 16

## Numbers of Children in Categories of Hand and Eye showing shifthandedness.

**Normal**

| | RH | | LH | | AMBI | | RH | LH |
|---|---|---|---|---|---|---|---|---|
| | RE | LE | RE | LE | RE | LE | | |
| **Boys** | | | | | | | | |
| S.H. | 0 | 1 | 14 | 7 | 1 | 2 | 1 | 21 |
| N.S.H. | 36 | 28 | 2 | 4 | 0 | 0 | 64 | 6 |
| **Girls** | | | | | | | | |
| S.H. | 0 | 1 | 1 | 3 | 3 | 0 | 1 | 4 |
| N.S.H. | 37 | 15 | 13 | 2 | 0 | - | 52 | 15 |

**Twin**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Boys** | | | | | | | | |
| S.H. | 0 | 0 | 23 | 11 | 1 | 1 | 0 | 34 |
| N.S.H. | 63 | 37 | 5 | 3 | 0 | 0 | 100 | 8 |
| **Girls** | | | | | | | | |
| S.H. | 0 | 0 | 20 | 14 | 3 | 0 | 0 | 34 |
| N.S.H. | 76 | 35 | 3 | 5 | 0 | 0 | 111 | 8 |

**Retarded**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Boys** | | | | | | | | |
| S.H. | 4 | 8 | 26 | 12 | 5 | 6 | 12 | 38 |
| N.S.H. | 65 | 56 | 7 | 1 | 0 | 0 | 121 | 8 |
| **Girls** | | | | | | | | |
| S.H. | 2 | 1 | 16 | 7 | 3 | 3 | 3 | 23 |
| N.S.H. | 46 | 29 | 0 | 3 | 0 | 0 | 75 | 3 |

## Appendix B

### Table 17

### Frequencies for the boy twins in family pairs older and younger.

Twin Boys (with 25 degrees of freedom).

| Older / Younger | | RH | | LH | | Ambi | | |
|---|---|---|---|---|---|---|---|---|
| | | RE | LE | RE | LE | RE | LE | |
| RH | RE | 11 | 3 | 3 | 2 | - | - | 19 |
| | LE | 6 | 4 | 3 | 1 | - | - | 14 |
| LH | RE | | 4 | 1 | - | - | 1 | 6 |
| | LE | | 1 | 1 | 1 | - | - | 3 |
| Ambi | RE | | 1 | | | | | 1 |
| | LE | - | - | - | - | - | - | - |
| | | 17 | 13 | 8 | 4 | | 1 | 43 |

$X^2 = 20.660$

### Table 18

### Frequencies for the girl twins in family pairs older and younger.

Twin Girls (with 25 degrees of freedom).

| Older / Younger | | RH | | LH | | Ambi | | |
|---|---|---|---|---|---|---|---|---|
| | | RE | LE | RE | LE | RE | LE | |
| RH | RE | 14 | 6 | 4 | 2 | | | 26 |
| | LE | 2 | 1 | 3 | 1 | | | 7 |
| LH | RE | 3 | 1 | 1 | 3 | | | 8 |
| | LE | 2 | 1 | 1 | 1 | 1 | | 6 |
| Ambi | RE | | 2 | | | | | 2 |
| | LE | - | - | - | - | - | - | - |
| | | 21 | 11 | 9 | 7 | 1 | | 49 |

$X^2 = 22.341$

## Appendix B

### Table 19

Boy and girl twins (with 25 degrees of freedom).

Younger / Older

| | | Boy older RH RE | Boy older RH LE | Boy older LH RE | Boy older LH LE | Girl older RH RE | Girl older RH LE | Girl older LH RE | Girl older LH LE | Ambi RE | Ambi LE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RH | RE | 3 | 8 | 6 | 4 | 1 | 6 | 1 | | 1 | | 11 | 19 |
| | LE | 2 | 3 | 4 | 2 | | | 1 | | | | 6 | 6 |
| LH | RE | 3 | 2 | | | | | 1 | 1 | 1 | | 5 | 3 |
| | LE | 1 | 2 | | | 1 | | | | 1 | | 2 | 3 |
| Ambi | RE | | | 1 | | 1 | | | | | | | 2 |
| | LE | | | 1 | | | | | | | | | 1 |
| | | 9 | 15 | 10 | 8 | 1 | 8 | 2 | 2 | 2 | 1 | 24 | 34 |

$X^2 = 14.421$ (Boy older)

$X^2 = 17.750$ (Girl older)

Boy and Girl twins together - $X^2 = 24.832$

The figures on the right of each column indicate the frequencies where the girl is older.

### Table 20

Boys (with 1 degree of freedom).

| Younger / Older | RH | LH | |
|---|---|---|---|
| RH | 24 | 9 | 33 |
| LH | 5 | 3 | 8 |
| | 29 | 12 | 41 |

$X^2 = .325$

These $X^2$ for such special groups were used to test handedness, eyedness and cross with pure.

## Appendix B

### Table 21

### $X^2$ values for Shifthandedness associated with speech difficulty.

**Normal Boys**

| | SH | NSH | |
|---|---|---|---|
| Sp. | 2 | 3 | 5 |
| N Sp. | 20 | 67 | 87 |
| | 22 | 70 | 92 |

$X^2 = 0.752$

**Normal Girls**

| | SH | NSH | |
|---|---|---|---|
| Sp. | 1 | - | 1 |
| N Sp. | 4 | 67 | 71 |
| | 5 | 67 | 72 |

$X^2 = 13.59^{xxx}$

**Twin Boys**

| | SH | NSH | |
|---|---|---|---|
| Sp. | 4 | 9 | 13 |
| N Sp. | 30 | 99 | 129 |
| | 34 | 108 | 142 |

$X^2 = 0.366$

**Twin Girls**

| | SH | NSH | |
|---|---|---|---|
| Sp. | 2 | 7 | 9 |
| N Sp. | 32 | 112 | 144 |
| | 34 | 119 | 153 |

$X^2 = 0.000$

**Retarded Boys**

| | SH | NSH | |
|---|---|---|---|
| Sp. | 6 | 9 | 15 |
| N Sp. | 44 | 120 | 164 |
| | 50 | 129 | 179 |

$X^2$ x 1.184

**Retarded Girls**

| | SH | NSH | |
|---|---|---|---|
| Sp. | 2 | 6 | 8 |
| N Sp. | 24 | 72 | 96 |
| | 26 | 78 | 104 |

$X^2 = 0.000$

Table 21 contd.

**Total Boys**

| | SH | NSH | |
|---|---|---|---|
| Sp. | 12 | 21 | 33 |
| N Sp. | 94 | 286 | 380 |
| | 106 | 307 | 413 |

$x^2 = 2.151$

**Total Girls**

| | SH | NSH | |
|---|---|---|---|
| Sp. | 5 | 13 | 18 |
| N Sp. | 60 | 251 | 311 |
| | 65 | 264 | 329 |

$x^2 = 0.773$

**Total Boys + Girls**

| | SH | NSH | |
|---|---|---|---|
| Sp. | 17 | 34 | 51 |
| N Sp. | 154 | 537 | 691 |
| | 171 | 571 | 742 |

$x^2 = 3.268$

## Appendix B

### Table 22

### Performance Test Results.

Total Girls Alone N = 341

**Twins**

| | Trial Test | | Final Test | |
|---|---|---|---|---|
| | P.H. | N.P.H. | P.H. | N.P.H. |
| Total Composite Score | 5086 | 3899 | 14312 | 11062 |
| % of poss. score | 23.45% | 17.98% | 32.30% | 24.96% |
| Av. Score per try | 32.6 | 14.9 | 91.7 | 70.9 |

**Retarded**

| | | | | |
|---|---|---|---|---|
| Total Composite Score | 3188 | 2651 | 8500 | 6886 |
| % of poss. score | 20.85% | 17.33% | 27.20% | 22.04% |
| Av. Score per try | 28.9 | 24.1 | 77.2 | 62.6 |

**Normals**

| | | | | |
|---|---|---|---|---|
| Total Composite Score | 2521 | 1877 | 6342 | 4640 |
| % of poss. score | 24.18% | 18.00% | 29.77% | 21.78% |
| Av. Score per try | 33.6 | 25. | 84.5 | 61.8 |

## Appendix B

## Table 23

### Performance Test Results.

Total Boys Alone N = 429

**Twins**

| | Trial Test | | Final Test | |
|---|---|---|---|---|
| | P.H. | N.P.H. | P.H. | N.P.H. |
| Total Composite Score | 5351 | 3985 | 13475 | 10419 |
| %vof poss. score | 26.73% | 19.90% | 32.94% | 25.47% |
| Av. Score per try | 37.1 | 27.6 | 93.5 | 72.3 |

**Retarded**

| | | | | |
|---|---|---|---|---|
| Total Composite Score | 6296 | 4950 | 16316 | 13657 |
| % of poss. score | 23.83% | 18.74% | 30.23% | 25.30% |
| Av. Score per try | 33.1 | 26. | 85.8 | 71.8 |

**Normals**

| | | | | |
|---|---|---|---|---|
| Total Composite Score | 3226 | 2699 | 8594 | 6908 |
| % of poss. score | 24.43% | 20.43% | 31.85% | 25.59% |
| Av. Score per try | 33.9 | 28.4 | 90.4 | 72.7 |

Appendix B

Table 24

Individual Performance Tests.

Total Av. Scores on Hoopla Test. All Girls (Total N = 341)

| Twins | Trial Test | | Final Test | |
|---|---|---|---|---|
| | P.H. | N.P.H. | P.H. | N.P.H. |
| Total Score | 1155 | 695 | 3660 | 2720 |
| % of poss. score | 16.4% | 9.9% | 19.5% | 14.5% |
| Av. Score | 7.4 | 4.4 | 23.4 | 17 |
| **Retarded** | | | | |
| Total Score | 655 | 420 | 1970 | 1450 |
| % of poss. score | 13.2% | 8.4% | 14.9% | 10.9% |
| Av. Score | 5.9 | 3.8 | 17.9 | 13. |
| **Normals** | | | | |
| Total Score | 555 | 355 | 1615 | 1005 |
| % of poss. score | 16.4% | 10.5% | 17.9% | 11.1% |
| Av. Score | 7.4 | 4.7 | 14.6 | 9.1 |
| Total Av. Score on Hoopla Test for All Girls | | | | |
| | 6.9 | 4.3 | 21.2 | 15. |

## Appendix B

### Table 25

Total Av. Scores on Hoopla Test. All Boys (Total N = 429)

| | Trial Test | | Final Test | |
|---|---|---|---|---|
| **Twins** | P.H. | N.P.H. | P.H. | N.P.H. |
| Total Score | 1390 | 790 | 3375 | 2470 |
| % of poss. score | 21.45% | 12.1% | 20.68% | 14.2% |
| Av. Score per try | 9.6 | 5.4 | 24.8 | 17. |
| **Retarded** | | | | |
| Total Score | 1525 | 845 | 4005 | 3315 |
| % of poss. score | 17.8% | 9.8% | 17.5% | 14.5% |
| Av. Score per try | 8. | 4.4 | 21 | 17.4 |
| **Normals** | | | | |
| Total Score | 710 | 510 | 2190 | 1675 |
| % of poss. score | 16.6% | 11.8% | 19.2% | 14.6% |
| Av. Score per try | 7.4 | 5.3 | 23. | 17.6 |
| **Total Av. Score on Hoopla Test for All Boys** | | | | |
| | 8.4 | 5. | 22.7 | 17.3 |

## Appendix B

### Table 26

### Individual Performance Tests.

Total Av. Scores on Bean Bag Test. All Girls (Total N = 341)

**Twins**

| | Trial Test | | Final Test | |
|---|---|---|---|---|
| | P.H. | N.P.H. | P.H. | N.P.H. |
| Total Score | 1085 | 645 | 4955 | 3315 |
| % of poss. score | 23.1% | 13.7% | 31.7% | 21.2% |
| Av. Score per try | 6.9 | 4.1 | 31.7 | 21.2 |
| **Retarded** | | | | |
| Total Score | 600 | 505 | 2650 | 1995 |
| % of poss. score | 18.1% | 15.3% | 24% | 18.1% |
| Av. Score per try | 5.4 | 4.5 | 24 | 18.1 |
| **Normals** | | | | |
| Total Score | 590 | 330 | 2060 | 1250 |
| % of poss. score | 26.2% | 14.5% | 27.4% | 16.6% |
| Av. score per try | 7.8 | 4.4 | 27.4 | 16.6 |
| Total Av. Score on Bean Bag Test for All Girls | | | | |
| | 6.6 | 4.3 | 28.3 | 19.2 |

## Appendix B

### Table 27

### Individual Performance Tests.

Total Av. Scores on Bean Bag Test. All Boys (Total N = 429)

**Twins**

| | Trial Test | | Final Test | |
|---|---|---|---|---|
| | P.H. | N.P.H. | P.H. | N.P.H. |
| Total Scpre | 1375 | 855 | 4765 | 3220 |
| % of poss. score | 31.8% | 19.7% | 33% | 22% |
| Av. Score per try | 9.5 | 5.9 | 33 | 22 |

**Retarded**

| | | | | |
|---|---|---|---|---|
| Total Score | 1400 | 970 | 5695 | 4220 |
| % of poss. score | 24.5% | 17.% | 29.9% | 22% |
| Av. Score per try | 7.3 | 5.1 | 29.9 | 22 |

**Normals**

| | | | | |
|---|---|---|---|---|
| Total Score | 750 | 600 | 2895 | 2120 |
| % of poss. score | 26.3% | 21% | 30.4% | 22.3% |
| Av. Score per try | 7.8 | 6.3 | 30.4 | 22.3 |

Total Av. Score on Bean Bag Test for All Boys

| | | | |
|---|---|---|---|
| 8.2 | 5.7 | 31.1 | 22.1 |

## Appendix B

### Table 28

### Individual Performance Tests.

Total Av. Scores on Peg Board Test. All Girls (N = 341)

| | Trial Test | | Final Test | |
|---|---|---|---|---|
| **Twins** | P.H. | N.P.H. | P.H. | N.P.H. |
| Total Score | 2846 | 2559 | 5697 | 5027 |
| % of poss. score | 30.88% | 27.8% | 61.82% | 54.52% |
| Av. Score per try | 18.2 | 16.4 | 36.5 | 32.2 |
| **Retarded** | | | | |
| Total Score | 1933 | 1726 | 3880 | 3441 |
| % of poss. score | 15.9% | 14.19% | 31.91% | 28.3% |
| Av. Score per try | 17.5 | 15.6 | 35.2 | 31.2 |
| **Normals** | | | | |
| Total Score | 1376 | 1192 | 2667 | 2385 |
| % of poss. score | 22.63% | 19.61% | 43.87% | 39.23% |
| Av. Score per try | 18.3 | 15.8 | 35.5 | 31.8 |
| Total Av. Score on Peg Board Test for All Girls | 18.0 | 16.0 | 35.9 | 31.8 |

## Appendix B

### Table 29

### Individual Performance Tests.

Total Av. Scores on Peg Board Test. All boys (Total N = 429)

| | Trial Test | | Final Test | |
|---|---|---|---|---|
| **Twins** | P.H. | N.P.H. | P.H. | N.P.H. |
| Total Score | 2586 | 2340 | 5135 | 4729 |
| % of poss. score | 28.06% | 25.39% | 55.72% | 51.31% |
| Av. Score | 17.9 | 16.2 | 35.6 | 32.8 |
| **Retarded** | | | | |
| Total Score | 3371 | 3135 | 6616 | 6122 |
| % of poss. score | 27.72% | 25.8% | 54.41% | 49.52% |
| Av. Score per try | 17.7 | 16.5 | 34.7 | 32.2 |
| **Normals** | | | | |
| Total Score | 1766 | 1589 | 3509 | 3113 |
| % of poss. score | 29.05% | 26.13% | 57.71% | 51.2% |
| Av. Score per try | 18.5 | 16.7 | 36.9 | 32.7 |
| Total Av. Score on Peg Board Test for All Boys | 17.9 | 16.4 | 35.5 | 32.5 |

Appendix B

Table 30

Normal Group Girls. N = 75

Total Van Riper Test Results
Composite Average Scores for
Consistent Mirrorers.

on

| | 3 Tests | | 2 Tests | | 1 Test | | |
|---|---|---|---|---|---|---|---|
| Category | No. | Av. Deg. Mirr. | No. | Av. Deg. Mirr. | No. | Av. Deg. Mirr. | No Mirr. Number |
| RH.RE | 18 | 47.3° | 4 | 65° | 4 | 85° | 2 |
| LH.LE | 4 | 43.3° | 0 | - | 0 | - | 0 |
| RH.LE | 10 | 43.4° | 4 | 66.2° | 2 | 45° | 0 |
| LH.RE | 10 | 44.4° | 1 | 75° | 2 | 75° | 0 |
| Ambi-R | 1 | 27° | 2 | 82.5° | 0 | - | 0 |
| Ambi-L | 0 | - | 0 | - | 0 | - | 0 |
| Totals | 43 | 44.67° | 11 | 69.54° | 8 | 72.5° | 2 |

Normal Group Girls. N = 75

Partial and Inconsistent Mirrorers.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| RH.RE | 9 | 52° | 0 | - | 0 | - | 0 |
| LH.LE | 0 | - | 1 | 60° | 0 | - | 0 |
| RH.LE | 0 | - | 0 | - | 0 | - | 0 |
| LH.RE | 0 | - | 1 | 65° | 0 | - | 0 |
| Ambi-R | 0 | - | 0 | - | 0 | - | 0 |
| Ambi-L | 0 | - | 0 | - | 0 | - | 0 |
| Totals | 9 | 52° | 2 | 62.5° | 0 | | 0 |

Appendix B

Table 31

Retarded Group Girls. N = 110

Total Van Riper Test Results
Composite Average Scores for
Consistent Mirrorers.

on

| | 3 Tests | | 2 Tests | | 1 Test | | |
|---|---|---|---|---|---|---|---|
| Category | No. | Av. Deg. Mirr. | No. | Av. Deg. Mirr. | No. | Av. Deg. Mirr. | No Mirr. Number |
| RH.RE | 34 | 41.6° | 9 | 58.3° | 1 | 40° | 0 |
| LH.LE | 9 | 65.4° | 1 | 65° | 0 | - | 0 |
| RH.LE | 20 | 39.2° | 3 | 36.6° | 1 | 60° | 1 |
| LH.RE | 12 | 48° | 0 | - | 1 | 40° | 0 |
| Ambi-R | 0 | - | 3 | 60° | 0 | - | 0 |
| Ambi-L | 0 | - | 2 | 85° | 0 | - | 0 |
| Totals | 75 | 44.86° | 18 | 58.33° | 3 | 46.6° | 1 |

Retarded Group Girls. N = 110

Partial and Inconsistent Mirrorers.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| RH.RE | 3 | 56.6° | 1 | 80° | 0 | - | 0 |
| LH.LE | 0 | - | 0 | - | 0 | - | 0 |
| RH.LE | 2 | 23° | 2 | 40° | 1 | 40° | 0 |
| LH.RE | 2 | 65° | 0 | - | 1 | 90° | - |
| Ambi-R | 0 | - | 0 | - | 0 | - | - |
| Ambi-L | 1 | 43° | 0 | - | 0 | - | 0 |
| Totals | 8 | 48.62° | 3 | 53.33° | 2 | 65° | 0 |

## Appendix B

### Table 32

### Twin Group Girls. N = 156

Total Van Riper Test Results
Composite Average Scores for
Consistent Mirrorers

on

| | 3 Tests | | 2 Tests | | 1 Test | | |
|---|---|---|---|---|---|---|---|
| Category | No. | Av. Deg. Mirr. | No. | Av. Deg. Mirr. | No. | Av. Deg. Mirr. | No Mirr. Number |
| RH.RE | 45 | 41.9° | 9 | 49.4° | 6 | 65° | 1 |
| LH.LE | 13 | 49° | 1 | 55° | 4 | 80° | 0 |
| RH.LE | 22 | 45° | 6 | 65° | 2 | 85° | 0 |
| LH.RE | 11 | 64.4° | 5 | 68° | 5 | 84° | 0 |
| Ambi-R | 0 | - | 1 | 65° | 0 | - | 0 |
| Ambi-L | 0 | - | 0 | - | 0 | - | 0 |
| Totals | 91 | 46.4° | 22 | 58.86° | 17 | 76.47° | 1 |

### Twin Group Girls. N = 156

Partial and Inconsistent Mirrorers.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| RH.RE | 8 | 51.30° | 7 | 82.1° | 0 | - | 0 |
| LH.LE | 1 | 50 | 0 | - | 0 | - | 0 |
| RH.LE | 3 | 49.6° | 2 | 60° | 0 | - | 0 |
| LH.RE | 1 | 33° | 1 | 70° | 0 | - | 0 |
| Ambi-R | 1 | 43° | 0 | - | 1 | 40° | 0 |
| Ambi-L | 0 | | 0 | - | 0 | - | 0 |
| Totals | 14 | 49° | 10 | 76.5° | 1 | 40° | 0 |

Appendix B

Table 33

Normal Group Boys. N = 95

Total Van Riper Test Results.
Composite Average Scores for
Consistent Mirrorers

on

| | 3 Tests | | 2 Tests | | 1 Test | | |
|---|---|---|---|---|---|---|---|
| Category | No. | Av. Deg. Mirr. | No. | Av. Deg. Mirr. | No. | Av. Deg. Mirr. | No Mirr. Number |
| RH.RE | 24 | 49.5° | 6 | 48.3° | 3 | 43.3° | 1 |
| LH.LE | 8 | 63.3° | 2 | 42.5° | 1 | 60° | 0 |
| RH.LE | 15 | 45.4° | 5 | 43° | 4 | 62.5° | 1 |
| LH.RE | 14 | 52.2° | 1 | 75° | 1 | 60° | 0 |
| Ambi-R | 0 | - | 1 | 45° | 0 | - | 0 |
| Ambi-L | 0 | - | 2 | 67.5° | 0 | - | - |
| Totals | 61 | 39.49° | 17 | 49.7° | 9 | 55.5° | 2 |

Normal Group Boys. N = 95

Partial and Inconsistent Mirrorers.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| RH.RE | 2 | 31.5° | 0 | - | 0 | - | 0 |
| LH.LE | 0 | - | 0 | - | 0 | - | 0 |
| RH.LE | 4 | 55.5° | 0 | - | 0 | - | 0 |
| LH.RE | 0 | - | 0 | - | 0 | - | 0 |
| Ambi-R | 0 | - | 0 | - | 0 | - | 0 |
| Ambi-L | 0 | - | 0 | - | 0 | - | 0 |
| Totals | 6 | 47.5° | 0 | - | 0 | - | 0 |

Appendix B

Table 34

Retarded Group Boys. N = 190

Total Van Riper Test Results
Composite Average Scores for
Consistent Mirrorers.

on

| Category | 3 Tests No. | 3 Tests Av. Deg. Mirr. | 2 Tests No. | 2 Tests Av. Deg. Mirr. | 1 Test No. | 1 Test Av. Deg. Mirr. | No Mirr. Number |
|---|---|---|---|---|---|---|---|
| RH.RE | 52 | 46.8° | 7 | 68.5° | 1 | 70° | 1 |
| LH.LE | 7 | 50.5° | 4 | 60° | 0 | - | 0 |
| RH.LE | 53 | 44.9° | 4 | 51.2° | 3 | 63.3° | 0 |
| LH.RE | 27 | 51.7° | 3 | 55° | 1 | 50° | 0 |
| Ambi-R | 0 | - | 3 | 55° | 0 | - | 0 |
| Ambi-L | 0 | - | 3 | 71.6° | 0 | - | 0 |
| Totals | 139 | 47.25° | 24 | 61.66° | 5 | 62° | 1 |

Retarded Group Boys. N = 190

Partial and Inconsistent Mirrorers.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| RH.RE | 3 | 53° | 4 | 65° | 1 | 80° | 0 |
| LH.LE | 2 | 64.5° | 0 | - | 0 | - | 0 |
| RH.LE | 4 | 51° | 0 | - | 0 | - | 0 |
| LH.RE | 2 | 48° | 0 | - | 0 | - | 0 |
| Ambi-R | 2 | 59.5° | 0 | - | 0 | - | 0 |
| Ambi-L | 3 | 28.6° | 0 | - | 0 | - | 0 |
| Totals | 16 | 49.56° | 4 | 65° | 1 | 80° | 0 |

Appendix B

Table 35

Twin Group Boys. N = 144.

Total Van Riper Test Results
Composite Average Scores for
Consistent Mirrorers.

on

| Category | 3 Tests No. | 3 Tests Av. Deg. Mirr. | 2 Tests No. | 2 Tests Av. Deg. Mirr. | 1 Test No. | 1 Test Av. Deg. Mirr. | No Mirr. Number |
|---|---|---|---|---|---|---|---|
| RH.RE | 45 | 47.6° | 10 | 64.5° | 2 | 65° | 1 |
| LH.LE | 10 | 58.3° | 2 | 45° | 1 | 90° | 0 |
| RH.LE | 26 | 45.1° | 6 | 55° | 1 | 70° | 1 |
| LH.RE | 17 | 53.5° | 4 | 65° | 2 | 60° | 0 |
| Ambi-R | 0 | - | 1 | 75° | 0 | - | 0 |
| Ambi-L | 0 | - | 0 | - | 0 | - | 0 |
| Totals | 98 | 49.08° | 23 | 58.26° | 6 | 68.3° | 2 |

Twin Group Boys. N = 144

Partial and Inconsistent Mirrorers.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| RH.RE | 1 | 60° | 3 | 46.6° | 1 | 40° | 0 |
| LH.LE | 1 | 46° | 0 | - | 0 | - | 0 |
| RH.LE | 2 | 36.5° | 1 | 20° | 0 | - | 0 |
| LH.RE | 5 | 53° | 0 | - | 0 | - | 0 |
| Ambi-R | 0 | - | 0 | - | 0 | - | 0 |
| Ambi-L | 1 | 53° | 0 | - | 0 | - | 0 |
| Totals | 10 | 50° | 4 | 40° | 1 | 40° | 0 |

## Appendix B

### Table 36

Normal Group Results - Visual Test - Girls (N = 75)

| Category | Consistent Mirrorers No. | Consistent Mirrorers Av. Deg. Mirr. | Partial Mirrorers No. | Partial Mirrorers Av. Deg. Mirr. | No Mirr. |
|---|---|---|---|---|---|
| RH.RE | 24 | 50.8° | 8 | 51.8° | 5 |
| LH.LE | 4 | 35° | 1 | 80° | 0 |
| RH.LE | 15 | 45.3° | 0 | - | 1 |
| LH.RE | 13 | 52.3° | 1 | 60° | 0 |
| Ambi-R | 3 | 63.3° | 0 | - | 0 |
| Ambi-L | 0 | - | 0 | - | 0 |
| Totals | 59 | | 10 | | 6 |

Consistent Mirrorers No. = 59 %= 78.6% Av. Deg. Mirr. = 49.3°
Partial Mirrorers No. = 10 %= 13.3% Av. Deg. Mirr. = 55.5°
No Mirroring No. = 6 %= 8%

Normal Group Results - Visual Test - Boys (N = 95)

| | | | | | |
|---|---|---|---|---|---|
| RH.RE | 33 | 51.21° | 2 | 55° | 1 |
| LH.LE | 11 | 67.2° | 0 | - | 0 |
| RH.LE | 22 | 41.81° | 5 | 60° | 2 |
| LH.RE | 16 | 53.7° | 0 | - | 0 |
| Ambi-R | 1 | 50° | 0 | - | 0 |
| Ambi-L | 2 | 50° | 0 | - | 0 |
| Totals | 85 | | 7 | | 3 |

Consistent Mirrorers No. = 85 %= 89.4% Av. Deg. Mirr. = 51.2°
Partial Mirrorers No. = 7 %= 7.3% Av. Deg. Mirr. = 58.5°
No Mirroring No. = 3 %= 3.1%

## Appendix B

### Table 37

**Normal Group Results - Script Test - Girls (N = 75)**

| | Consistent Mirrorers | | Partial Mirrorers | | |
|---|---|---|---|---|---|
| Category | No. | Av. Deg. Mirr. | No. | Av. Deg. Mirr. | No Mirr. |
| RH.RE | 30 | 49.3° | 0 | 0 | 7 |
| LH.LE | 4 | 55° | 0 | - | 1 |
| RH.LE | 12 | 58.3° | 0 | - | 4 |
| LH.RE | 11 | 54.5° | 0 | - | 3 |
| Ambi-R | 1 | 20° | 0 | - | 2 |
| Ambi-L | 0 | - | 0 | - | 0 |
| Totals | 58 | | 0 | | 17 |

Consistent Mirrorers No. = 58 %= 77.3% Av. Deg. Mirr. = 52°
Partial Mirrorers No. = 0
No Mirroring No. = 17 %= 22.6%

**Normal Group Results - Script Test - Boys (N = 95)**

| | | | | | |
|---|---|---|---|---|---|
| RH.RE | 29 | 50° | 0 | - | 7 |
| LH.LE | 9 | 64.4° | 0 | - | 2 |
| RH.LE | 22 | 54.5° | 1 | 80° | 6 |
| LH.RE | 15 | 60.6° | 0 | - | 1 |
| Ambi-R | 1 | 40° | 0 | - | 0 |
| Ambi-L | 2 | 85° | 0 | - | 0 |
| Totals | 78 | | 1 | | 16 |

Consistent Mirrorers No. = 78 %= 82.1% Av. Deg. Mirr. = 55.7°
Partial Mirrorers No. = 1 %= 1% Av. Deg. Mirr. = 80°
No Mirrorers No. = 16 %= 16.8%

Appendix B

Table 38

Normal Group Results - Kinaesthetic Test - Girls (N = 75)

| Category | Consistent Mirrorers No. | Av. Deg. | Av. Time | Partial Mirrorers No. | Av. Deg. | Av. Time | No Mirror |
|---|---|---|---|---|---|---|---|
| RH.RE | 27 | 47.4° | 167.4" | 2 | 60° | 127.5" | 8 |
| LH.LE | 5 | 40° | 218" | 0 | - | - | 0 |
| RH.LE | 13 | 41.5° | 163.1" | 0 | - | - | 3 |
| LH.RE | 11 | 35.4° | 131.7" | 0 | - | - | 3 |
| Ambi-R | 2 | 75° | 90" | 1 | 50° | 80" | 0 |
| Ambi-L | 0 | - | - | 0 | - | - | 0 |
| Totals | 58 | | | 3 | | | 14 |

Consistent Mirrorers No.=58 %=77.3% Av. Deg. Mirr. =44.1° Av. Time=161.3"
Partial Mirrorers No.= 3 %= 4% Av. Deg. Mirr. =56.5° Av. Time=111.6"
No Mirroring No.=14 %=18.6%

Normal Group Results - Kinaesthetic Test - Boys (N = 95)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| RH.RE | 29 | 42.06° | 143.3" | 0 | - | - | 7 |
| LH.LE | 9 | 47.4° | 156.1" | 0 | - | - | 2 |
| RH.LE | 21 | 45.23° | 154.2" | 1 | 40° | 85" | 7 |
| LH.RE | 14 | 45° | 109.6" | 0 | - | - | 2 |
| Ambi-R | 0 | - | - | 0 | - | - | 1 |
| Ambi-L | 0 | - | - | 0 | - | - | 2 |
| Totals | 73 | | | 1 | | | 21 |

Consistent Mirrorers No.=73 %=76.8% Av. Deg. Mirr. =44.2° Av. Time=141.6"
Partial Mirrorers No.= 1 %= 1% Av. Deg. Mirr. =40° Av. Time= 85"
No Mirroring No.=21 %=22.1%

Appendix B

Table 39

Retarded Group Results - Visual Test - Girls (N = 110)

| | Consistent Mirrorers | | Partial Mirrorers | | |
|---|---|---|---|---|---|
| Category | No. | Av. Deg. Mirr. | No. | Av. Deg. Mirr. | No Mirr. |
| RH.RE | 44 | 45.6° | 4 | 50° | 0 |
| LH.LE | 10 | 65° | 0 | - | 0 |
| RH.LE | 24 | 41.2° | 5 | 40° | 1 |
| LH.RE | 13 | 43.8° | 3 | 80° | 0 |
| Ambi-R | 3 | 63.3° | 0 | - | 0 |
| Ambi-L | 2 | 80° | 1 | 30° | 0 |
| Totals | 96 | | 13 | | 1 |

Consistent Mirrorers No. = 96 %= 87.2% Av. Deg. Mirr. = 47.6°
Partial Mirrorers No. = 13 %= 11.8% Av. Deg. Mirr. = 51.5°
No Mirrorers No. = 1 %= .90%

Retarded Group Results - Visual Test - Boys (N = 190)

| | | | | | |
|---|---|---|---|---|---|
| RH.RE | 60 | 51.1° | 8 | 70° | 1 |
| LH.LE | 10 | 54° | 2 | 60° | 1 |
| RH.LE | 58 | 47.7° | 4 | 62.5° | 2 |
| LH.RE | 31 | 57.7° | 2 | 60° | 0 |
| Ambi-R | 3 | 56.6° | 2 | 45° | 0 |
| Ambi-L | 3 | 66.6° | 3 | 46.6° | 0 |
| Totals | 165 | | 21 | | 4 |

Consistent Mirrorers No. = 165 %= 86.8% Av. Deg. Mirr. = 51.7°
Partial Mirrorers No. = 21 %= 11.0% Av. Deg. Mirr. = 60.9°
No Mirroring No. = 4 %= 2.1%

Appendix B

Table 40

Retarded Group Results - Script Test - Girls (N = 110)

| | Consistent Mirrorers | | Partial Mirrorers | | |
|---|---|---|---|---|---|
| Category | No. | Av. Deg. Mirr. | No. | Av. Deg. Mirr. | No Mirr. |
| RH.RE | 39 | 45.1° | 0 | - | 9 |
| LH.LE | 9 | 65.5° | 0 | - | 1 |
| RH.LE | 25 | 41.2° | 0 | - | 5 |
| LH.RE | 14 | 58.5° | 0 | - | 2 |
| Ambi-R | 3 | 56.6° | 0 | - | 0 |
| Ambi-L | 2 | 90° | 0 | - | 1 |
| Totals | 92 | | 0 | | 18 |

Consistent Mirrorers No. = 92 %= 83.6% Av. Deg. Mirr. = 49.4°
Partial Mirrorers No. = 0
No Mirroring No. = 18 %= 16.3%

Retarded Group Results - Script Test - Boys (N = 190)

| | | | | | |
|---|---|---|---|---|---|
| RH.RE | 64 | 56.2° | 0 | - | 5 |
| LH.LE | 11 | 59° | 0 | - | 2 |
| RH.LE | 61 | 48.8° | 0 | - | 3 |
| LH.RE | 30 | 50.6° | 0 | - | 3 |
| Ambi-R | 4 | 85° | 0 | - | 1 |
| Ambi-L | 4 | 50° | 1 | 30° | 1 |
| Totals | 174 | | 1 | | 15 |

Consistent Mirrorers No. = 174 %= 91.5% Av. Deg. Mirr. = 53.3°
Partial Mirrorers No. = 1 %= .52%Av. Deg. Mirr. = 30°
No Mirroring No. = 15 %= 7.8%

## Appendix B

### Table 41

**Retarded Group Results - Kinaesthetic Test - Girls (N = 110)**

| Category | Consistent Mirrorers No. | Av. Deg. | Av. Time | Partial Mirrorers No. | Av. Deg. | Av. Time | No Mirror. |
|---|---|---|---|---|---|---|---|
| RH.RE | 43 | 44.4° | 139.5" | 0 | - | - | 5 |
| LH.LE | 10 | 66° | 209.5" | 0 | - | - | 0 |
| RH.LE | 24 | 32.2° | 205.7" | 0 | - | - | 6 |
| LH.RE | 14 | 44.2° | 179" | 0 | - | - | 2 |
| Ambi-R | 0 | - | - | 0 | - | - | 3 |
| Ambi-L | 2 | 50° | 157.5" | 0 | - | - | 1 |
| Totals | 93 | | | 0 | | | 17 |

Consistent Mirrorers No.=93 %=84.5% Av. Deg. Mirr. =43.7° Av. Time=170.4%
Partial Mirrorers No.= 0
No Mirroring No.=17 %=15.4%

**Retarded Group Results - Kinaesthetic Test - Boys (N = 190)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| RH.RE | 57 | 37.5° | 158.1" | 0 | - | - | 12 |
| LH.LE | 12 | 51.6° | 152.6" | 0 | - | - | 1 |
| RH.LE | 59 | 39.6° | 189.3" | 0 | - | - | 5 |
| LH.RE | 32 | 45° | 176.3" | 0 | - | - | 1 |
| Ambi-R | 3 | 36.6° | 116.6" | 0 | - | - | 2 |
| Ambi-L | 4 | 30° | 155" | 0 | - | - | 2 |
| Totals | 167 | | | 0 | | | 23 |

Consistent Mirrorers No.=167 %=87.8% Av. Deg. Mirr. =40.5° Av. Time=171.4
Partial Mirrorers No.= 0
No Mirroring No.= 23 %=12.1%

## Appendix B

### Table 42

### Twin Group Results - Visual Test - Girls (N = 156)

| | Consistent Mirrorers | | Partial Mirrorers | | |
|---|---|---|---|---|---|
| Category | No. | Av. Deg. Mirr. | No. | Av. Deg. Mirr. | No Mirr. |
| RH.RE | 57 | 48.2° | 15 | 61.3° | 4 |
| LH.LE | 17 | 58.2° | 1 | 10° | 1 |
| RH.LE | 30 | 58° | 5 | 53.8° | 0 |
| LH.RE | 21 | 74.7° | 2 | 50° | 0 |
| Ambi-R | 1 | 90° | 2 | 45° | 0 |
| Ambi-L | 0 | - | 0 | - | 0 |
| Totals | 126 | | 25 | | 5 |

Consistent Mirrorers No. = 126 %= 80.7% Av. Deg. Mirr. = 56.6°
Partial Mirrorers No. = 25 %= 16.0% Av. Deg. Mirr. = 55.5°
No Mirroring No. = 5 %= 3.2%

### Twin Group Results - Visual Test - Boys (N = 144)

| | | | | | |
|---|---|---|---|---|---|
| RH.RE | 56 | 56.4° | 5 | 44° | 2 |
| LH.LE | 12 | 51.6° | 1 | 50° | 1 |
| RH.LE | 29 | 52.4° | 6 | 48.3° | 2 |
| LH.RE | 21 | 59° | 5 | 46° | 2 |
| Ambi-R | 1 | 90° | 0 | - | 0 |
| Ambi-L | 0 | - | 1 | 60° | 0 |
| Totals | 119 | | 18 | | 7 |

Consistent Mirrorers No. = 119 %= 82.6% Av. Deg. Mirr. = 55.7°
Partial Mirrorers No. = 18 %= 12.5% Av. Deg. Mirr. = 47.2°
No Mirroring No. = 7 %= 4.8%

## Appendix B

### Table 43

### Twin Group Results - Script Test - Girls (N = 156)

| Category | Consistent Mirrorers No. | Consistent Mirrorers Av. Deg. Mirr. | Partial Mirrorers No. | Partial Mirrorers Av. Deg. Mirr. | No Mirr. |
|---|---|---|---|---|---|
| RH.RE | 66 | 47.4° | 0 | - | 10 |
| LH.LE | 15 | 60° | 0 | - | 4 |
| RH.LE | 31 | 53.5° | 0 | - | 4 |
| LH.RE | 17 | 67° | 0 | - | 6 |
| Ambi-R | 2 | 65° | 0 | - | 1 |
| Ambi-L | 0 | - | 0 | - | 0 |
| Totals | 131 | | 0 | | 25 |

Consistent Mirrorers No. = 131 %= 83.9% Av. Deg. Mirr. = 53.1°
Partial Mirrorers No. = 0
No Mirroring No. = 25 %= 16%

### Twin Group Results - Script Test - Boys (N = 144)

| | | | | | |
|---|---|---|---|---|---|
| RH.RE | 56 | 50° | 0 | - | 7 |
| LH.LE | 12 | 68.3° | 0 | - | 2 |
| RH.LE | 35 | 42.5° | 0 | - | 2 |
| LH.RE | 25 | 60.8° | 0 | - | 3 |
| Ambi-R | 1 | 60° | 0 | - | 0 |
| Ambi-L | 1 | 90° | 0 | - | 0 |
| Totals | 130 | | 0 | | 14 |

Consistent Mirrorers No. = 130 %= 90.2% Av. Deg. Mirr. = 52.1°
Partial Mirrorers No. = 0
No Mirroring No. = 14 %= 9.7%

Table 44

Twin Group Results - Kinaesthetic Test - Girls (N = 156)

| | Consistent Mirrorers | | | Partial Mirrorers | | | |
|---|---|---|---|---|---|---|---|
| Category | No. | Av. Deg. | Av. Time | No. | Av. Deg. | Av. Time | No Mirror. |
| RH.RE | 56 | 40.8° | 175.7" | - | - | - | 20 |
| LH.LE | 15 | 39.3° | 169.2" | 0 | - | - | 4 |
| RH.LE | 27 | 34.4° | 129.5" | 0 | - | - | 8 |
| LH.RE | 13 | 50° | 119.1" | 0 | - | - | 10 |
| Ambi-R | 2 | 30° | 125" | 0 | - | - | 1 |
| Ambi-L | 0 | - | - | 0 | - | - | 0 |
| Totals | 113 | | | 0 | | | 43 |

Consistent Mirrorers No.=113 %=72.4% Av. Deg. Mirr. =40° Av. Time=156.4"
Partial Mirrorers No.= 0
No Mirroring No.= 43 %=27.5%

Twin Group Results - Kinaesthetic Test - Boys (N = 144)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| RH.RE | 50 | 42.8° | 133.5" | 0 | - | - | 13 |
| LH.LE | 13 | 42.3° | 138.1" | 0 | - | - | 1 |
| RH.LE | 30 | 41.3° | 140.3" | 0 | - | - | 7 |
| LH.RE | 25 | 47.2° | 156.2" | 0 | - | - | 3 |
| Ambi-R | 0 | - | - | 0 | - | - | 1 |
| Ambi-L | 1 | 10° | 130" | 0 | - | - | 0 |
| Totals | 119 | | | 0 | | | 25 |

Consistent Mirrorers No.=119 %=82.6% Av. Deg. Mirr. =43.0° Av. Time = 140.4"
Partial Mirrorers No.= 0
No Mirroring No.= 25 %=17.3%